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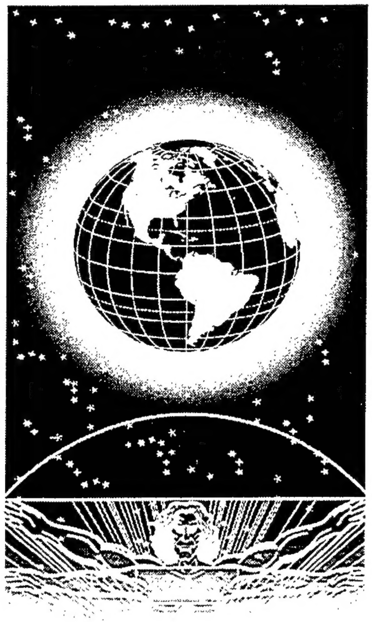

UNITED STATES AIR FORCE RESEARCH LABORATORY

Aircraft Battle Damage Assessment and Repair (ABDAR) Final Program Report

Volume 3: Field Test Report

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FOR THE COMMANDER

Mark M. Hoffman

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13. ABSTRACT *(Maximum 200 words)*
This is the last of three volumes describing the results of a program to develop technology to enhance the aircraft battle damage assessment and repair (ABDAR) process. This volume describes the results of a field test conducted to evaluate the ABDAR Demonstration System. The system was evaluated by comparing the performances of technicians performing a simulated aircraft battle damage assessment task using the ABDAR demonstration system with the performances of technicians performing the task with conventional paper-based technical orders (TOs). The study compared two types of electronic technical data presented on the ABDAR Demonstration System (Content Data Model [CDM] and Indexed Portable Document Format [IPDF]) with the performance of technicians using paper TOs. Dependent variables of speed, accuracy, and completeness were measured. Subjects using the ABDAR Demonstration System with CDM data performed significantly faster than subjects using the ABDAR Demonstration System with IPDF data, improving the overall time by 86%. Subjects using CDM and IPDF data were significantly more accurate and complete than subjects using Paper, regardless of technician type. Assessments by subjects using CDM were 39% more complete and 51% more accurate than assessments conducted by subjects using paper TOs. Assessments by subjects using IPDF were 34% more complete and 44% more accurate than assessments by subjects using paper TOs. Overall, the ABDAR Demonstration System tools, in conjunction with electronic technical data, provided a significant advantage over the current, paper-based method of performing ABDAR assessments.

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PREFACE

The research documented in this technical report was sponsored by the Air Force Research Laboratory, Deployment and Sustainment Division, Logistics Readiness Branch. This volume is the third of three volumes that summarize work performed to develop an Aircraft Battle Damage Assessment and Repair (ABDAR) technology to enhance the capability of Air Force technicians to assess damage, determine needed repairs and restore the aircraft to operational status. The work was funded under PE63106F, Project 2745. The work was performed under contract F41624-95-C-5003 by NCI Information Systems, Inc., with subcontractor support from Boeing Aircraft Company, RJO Enterprises, Inc., and GRACAR Corporation. Captain Michael Clark and 1st Lieutenant Steve Grace were the program managers for the major portion of the effort. Other Laboratory personnel who made major contributions earlier in the program were Captain Eric Carlson, Captain Floyd Gwartney, 1st Lieutenant J.C. Bradford, and 1st Lieutenant Maurice Azar.

This research could not have been accomplished without the support and assistance of many members of the Combat Logistics Support Squadrons, the Aircraft Battle Damage Repair Program Office, and the Air Force Materiel Command Logistics Directorate who served as members of the ABDAR Users Group, provided technical guidance throughout the program, and provided program advocacy.

The 653rd Combat Logistics Support Squadron, Robins AFB provided extraordinary support for the program. The 653rd provided the test facilities, test aircraft, and many of the technicians who participated in the field test. The squadron also provided the support of several of their instructors who served as subject matter experts and advisors throughout the program. The contributions of MSgt Ken McCain, TSgt Geoffrey Miller, TSgt George Boutwell, TSgt Ken Dockery, and TSgt Rob Meyers as technical advisors were invaluable and greatly appreciated by the ABDAR program staff.

The Field Test Report is the third volume of a three-volume final program report. It describes the objectives, methodology, and results of the ABDAR field test.

SUMMARY

The objective of the Aircraft Battle Damage Assessment and Repair (ABDAR) program was to develop and demonstrate technology to provide Aircraft Battle Damage Repair (ABDR) technicians and assessors with ready access to specialized tools and the technical information required to perform their jobs. The ABDAR program developed and field-tested the techniques and technologies required to implement an operational ABDAR System. Technological developments include advances in the areas of Interactive Electronic Technical Manuals (IETMs), computer-generated diagnostics, human/computer interface, portable maintenance aids (PMAs), and the use of complex databases. These advances were incorporated into the ABDAR Demonstration System for evaluation under simulated field conditions.

This volume of the technical report describes the results of a field test conducted to evaluate the ABDAR Demonstration System. The system was evaluated by comparing the performances of technicians performing a simulated aircraft battle damage assessment task using the ABDAR demonstration system with the performances of technicians performing the task with conventional paper based technical orders (TOs). The study compared two types of electronic technical data presented on the ABDAR Demonstration System (Content Data Model [CDM], Indexed Portable Document Format [IPDF]) with the performance of technicians using paper TOs. Dependent variables of speed, accuracy, and completeness were measured. Subjects using the ABDAR Demonstration System with CDM data performed significantly faster than subjects using the ABDAR Demonstration System with IPDF data, improving the overall time by 86%. Subjects using CDM and IPDF data were significantly more accurate and complete than subjects using Paper, regardless of technician type. Assessments by subjects using CDM were 39% more complete and 51% more accurate than assessments conducted by subjects using paper TOs. Assessments by subjects using IPDF were 34% more complete and 44% more accurate than subjects using Paper TOs. Overall, the ABDAR Demonstration System tools, in conjunction with electronic technical data, provided a significant advantage over the current, paper-based method of performing ABDR assessments.

In addition to the demonstrated performance enhancements to ABDR, the ABDAR Demonstration System has a high rate of acceptance among the potential users. Users expressed a strong desire to have an ABDAR system implemented for operational use.

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INTRODUCTION

The objective of the ABDAR program was to develop an ABDAR Demonstration System that would significantly enhance the speed, accuracy, and completeness of the assessment of damage inflicted on an aircraft during combat operations. The ABDAR Demonstration System developed in the ABDAR program was an end-to-end system. The process started at aircraft Debrief and finished with final documentation of the damage on an Air Force Technical Order (AFTO) Form 97. The ABDR process and requirements were supported with technical data from applicable ABDR manuals for a range of aircraft systems, including TO 1-1H-39, Technical Manual, General Aircraft Battle Damage Repair. The system supports two different Electronic Technical Information (ETI) types, Integrated Portable Document File (IPDF) and Content Data Model (CDM). This volume reports the results of a field test to evaluate the ABDAR Demonstration System.

Data collection was conducted by AFRL/HESR, with technical and administrative support provided by NCI and Boeing. Analysis of data and report writing for the test was accomplished by NCI. The field test provided a structured approach to the testing of the ABDAR Demonstration System. The field test was conducted at Robins AFB between September 1998 and October 1999. The test consisted of two distinct phases: Phase I - ABDAR process Paper Technical Data version and Phase II - ABDAR process ETI version. This report presents the findings from the field test and provides recommendations for implementation of the ABDAR technology.

Background

The ABDAR program was an advanced development research and development (R&D) project under the sponsorship of Air Force Research Laboratory's Logistics Readiness Branch (AFRL/HESR). The requirement was to develop and demonstrate technology that would provide a significant enhancement in the capability of USAF ABDR assessors and technicians to rapidly assess battle damaged aircraft. These individuals face the critical task of assessing, repairing, and returning battle-damaged aircraft to mission readiness during wartime. AFRL/HESR and the USAF and Department of Defense (DoD) ABDR communities have long recognized that enhancements to this capability are critical to success in future armed conflicts. The development of an enhanced aircraft battle damage repair (ABDR) assessment capability will provide an effective force multiplier to the Combat Air Forces (CAF).

The 55-month ABDAR program supported a concept developed in the early 1990's by AFRL/HESR. A preliminary demonstration of the concept was developed in 1994. The preliminary demonstration effort focused on devising a process to enhance the assessment and repair methodology within the Integrated Maintenance Information System (IMIS) program (Ward, et al. 1995, Volumes 1, 2, 3, and Thomas, 1995). The preliminary demonstration was intended to be used as a module that would be tailored specifically for the assessor's use in an IMIS environment. A principle of IMIS was the integration of multiple sources of maintenance information. This concept was a guiding principle for the ABDAR program. The development challenge was to provide that information through a common user interface that operates off a workstation or a portable maintenance aid (PMA) and effectively provides the ABDR assessor with all of the information required to perform the damage assessment.

The preliminary ABDAR concept demonstration was presented at an ABDR "Live-Fire" Demonstration Exercise conducted at Davis-Monthan AFB, Arizona in October-November 1994. The AF and DoD ABDR User Community representatives who viewed the demonstration were highly receptive to the AFRL concept and encouraged further development of the concept and technology.

That fundamental ABDAR research evolved into this technology development effort. The approach was to perform a requirements analysis that would feed "as is" and "to be" modeling data and system requirements into the design, development, data authoring, integration, and testing of an ABDAR Demonstration System. Those processes started in August 1995 and culminated with the development of the ADBAR Demonstration System for use at the field test in 1999-2000. Throughout the program, AF and DoD users from the ABDR community were actively involved in the development of the ABDAR Demonstration System and the planning and implementation of the field test. The field test focused on the "assessment" portion of the ABDR process. The demonstration system developed provided the means to support multiple levels of ETI including Level II (IPDF type data) and Level IV, (CDM type data). Development of the ABDAR Demonstration System is described in detail in Volume 2 of this report.

Field Test Goals

The goal of the ABDAR field test was to evaluate the ABDAR concept, as implemented in the ABDAR Demonstration System, in a simulated ABDR environment. Specifically, the field test was designed to answer the following questions.

a. Can ABDR assessors more effectively perform the damage assessment and repair planning processes when using the ABDAR Demonstration System than when using paper technical orders?

b. Are technicians who perform the ABDR assessment and repair planning processes more effective when using ABDAR Demonstration System with CDM data than technicians using the system with IPDF data?

c. Is there a difference in the performance of F-15 ABDR qualified assessors and the performance of ABDR assessors qualified on other aircraft?

d. Can F-15 mechanics perform the assessment process on the F-15 as efficiently as F-15 and other aircraft qualified assessors?

Programmatic Parameters

The following field test parameters are provided as an overview of the field test.

a. The field test was conducted by AFRL/HESR with contractor support from NCI.

b. The field test spanned a period of one year, with actual data collection consuming nine weeks of that time. Three weeks of testing occurred for each of the three media types.

c. An F-15A aircraft was available for the duration of the testing. The damages, previously inflicted on the aircraft, remained unchanged for all subjects. The damages inflicted on the aircraft accurately simulate typical damage received in combat operations.

d. Dedicated hangar space was available for use in all data collection activities. The hangar space was the same for the pre-field test and the field test.

e. A pre-field test was conducted before each phase of the actual test. Its purpose was:

   (1) To verify the test procedures.

   (2) To confirm that all system components functioned as planned.

   (3) To train the evaluation team members on the use of the system and data collection procedures.

Field Test Hardware and Software Requirements

The field test implementation of the ABDAR Demonstration System required three integrated hardware segments. See volume 2, Program Methodology, for specific details on the system architecture. See Figure 1 below for a graphic representation of the system.

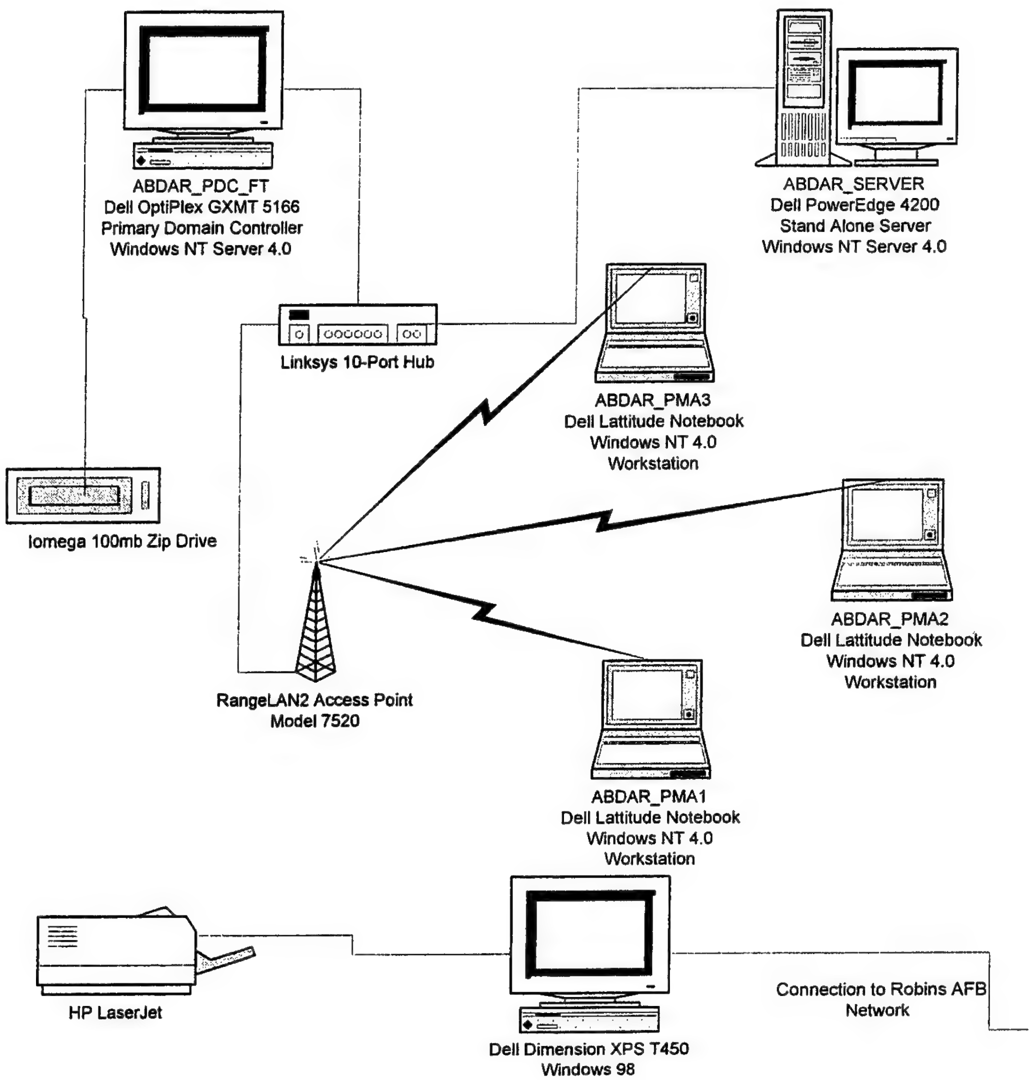

Figure 1 – Field Test Hardware Design

a. PMA - a laptop computer used to provide technical information for use by assessors performing the assessment task. Also, the PMA was used to record damage information, repairs, and for communications. Information provided via the PMA included those TOs required to successfully perform an ABDR assessment. These included the general and F-15 specific –39 TOs, TOs for aircraft structures, and TOs for relevant aircraft systems. Two PMAs were used during the field test, one by the subject (client PMA) and one by the field test administrator (for communication and administration). One PMA acted as the client portion of the three-tier architecture. The PMA provided information in either the CDM format or the IPDF format.

b. Server - a server computer system used as the information repository for the ABDAR Demonstration System databases. The ABDAR Server executed the database server software and the application server software. The ABDAR

Server was used for storing and providing access to the IPDF files, CDM data, and ABDAR System data.

c. Administration Workstation - a desktop computer system used by ABDAR team software engineers responsible for maintaining the ABDAR Demonstration System. The workstation was used by software engineers to perform backups and to maintain system configuration. Support personnel responsible for conducting the field test (electronic communication and field test documentation) also used this device.

For the field test, the ABDAR Demonstration System required the hardware and software shown in Table 1. All of the devices were configured with radio frequency (RF) modems, providing for wireless communication. Additionally, 10-Base T Ethernet connections were used in all devices, allowing for rapid data transfers, communication to home station, and backup for the wireless communication. The ABDAR server had a 24-hour service agreement with the vendor (Dell Computer Corporation), full backup capabilities, and an uninterruptible power supply (UPS) ensuring complete support for the field test.

Table 1 - ABDAR Field Test Hardware and Software Configuration

Equipment	#	Configuration Requirements	Applications/Accessories
ABDAR PMA	5 (2 for subject use in test and 3 for back-up)	256MB RAM 6 GB HD Win 95/NT with Pentium class processor	Java Runtime Environment 1.1.7a Adobe Acrobat Exchange 3.01 (for IPDF viewing) ABDAR Java components
ABDAR Server (Running application server, and database servers)	1	256MB RAM 5 Hard Drives configured with RAID Level 2 (4 GB each) Win NT with more than one Pentium Pro or Pentium II processors	Application Server (Tengah 3.1) Database Server (Oracle Enterprise Server 7.3) ABDAR Java components
ABDAR Admin Workstation (Test Team Support)	1	256MB RAM 6 GB HD Win 95/NT with Pentium class processor	Java Runtime Environment 1.1.7a Microsoft Office 97 Suite IPDF Viewing Capabilities (Adobe Acrobat Exchange 3.01) Database Management Capabilities (Oracle Enterprise Manager) Application Management Capabilities (Tengah Manager) ABDAR Java components

FIELD TEST

The ABDAR field test was conducted in a simulated ABDR environment. The test scenario(s) were developed to represent a typical battle damage assessment situation. Data was collected and analyzed, with conclusions being drawn based on the following objectives. Additionally, this section outlines the field test rules, scenarios, and data collection considerations.

Objectives

The objectives of the ABDAR field test were to:

1. Collect data to support statistical conclusions regarding the following hypotheses.

   a. The F-15 Assessor using CDM data with ABDAR will perform significantly better (fewer errors, less time, more complete assessment) than the F-15 Assessor using paper.

   b. The Other Assessor using CDM data with ABDAR will perform significantly better (fewer errors, less time, more complete assessment) than the F-15 Assessor using paper.

   c. There will be a significant performance difference (fewer errors, less time, more complete assessment) among technicians when using CDM data with ABDAR.

   d. There will be a significant performance difference (fewer errors, less time, more complete assessment) among technicians when using IPDF data with ABDAR.

   e. The F-15 Assessor will perform significantly better (fewer errors, less time, more complete assessment) using CDM data with ABDAR than when using IPDF data with ABDAR.

   f. There will be a significant interaction between technician type and media on both errors and time. CDM data with ABDAR will tend to minimize the differences between technician types while the Paper media with ABDAR will show large differences between technician types. The interaction will be ordinal in nature, meaning the relative ranking of the technician types will remain the same at all three levels of media.

2. To collect user feedback data on the system, including recommendations for improvements.

Field Test Experimental Design Considerations

The original field test plan provided for a two way ANOVA with three treatment variables (CDM, IPDF, Paper) and three categories of subjects (F-15 ABDR assessors, ABDAR assessors qualified on other aircraft, and F-15 mechanics). The design required that all subjects be qualified at skill level-7 (7-level) in their Air Force Specialties. However, a sufficient number of 7-level F-15 mechanics were not available, requiring the substitution of 5-level mechanics. Since the relative skill levels of the F-15 mechanic subjects was no longer comparable to the skill levels of the F-15 and other aircraft assessors, it was not possible to directly compare their performance with the performance of the F-15 assessors and other aircraft assessors. A separate analysis was performed on the F-15 mechanic data. This change had the effect of breaking the field test into two experiments.

The first experiment (F-15 and other aircraft assessors) was a 2 x 3 factorial design with technician type (F-15 Assessor and Other Assessor) and media type (Paper, IPDF, and CDM) as the independent variables. Dependent variables were Time, Accuracy, and Completeness. Separate Analysis of Variance (ANOVA) tests were performed on each dependent variable. Subjects for the first study consisted of 30 USAF maintenance Air Force Specialty (AFS) 7-level qualified individuals. Fifteen were ABDAR qualified F-15 assessors and 15 were ABDAR qualified assessors on other aircraft (e.g., C-130, F-16).

The second experiment was a 1 x 3 design with F-15 Mechanics performing the same tasks as above with the three media types (Paper, IPDF, and CDM). Dependent variables were time, accuracy, and completeness. Separate One-Way Analysis of Variance (ANOVA) tests were performed on each dependent variable. Subjects consisted of 18 USAF maintenance AFS 5 and 7-level qualified individuals. The results of this experiment are summarized in Appendix A.

After the field test was completed, additional data was gathered to address a question raised in the analysis of the field test data. The additional data was collected to address the issue of whether performance advantages observed for the ABDAR IPDF data were due to the implementation of IPDF data in the ABDAR system or due to the fact that the data is presented electronically. In other words, would the same performance advantages have been observed if the IPDF data had been presented in its basic form without the enhancements and aids provided by the ABDAR System? The findings of this additional data collection are presented in Appendix B.

<u>Subjects</u>

For both experiments, subject assignment was randomized to minimize spurious effects of order, shift, experimenter, and other non-experimental variables. For randomized subject assignments see APPENDIX C – FIELD TEST SCHEDULE, Table C- 1 – Paper Schedule, Table C- 2 – Electronic One Schedule, and Table C- 3 – Electronic Two Schedule.

A total of Fifty-three subjects participated in the two experiments. All subjects were identified before the start of the experiment. Every effort was made to avoid substitutions. One F-15 assessor was unable to complete the testing, reducing the total number of subjects to 53 and the number of subjects used in the main analysis to 30[1] for Experiment One and 18 subjects for Experiment Two.

The subjects for the first experiment were fifteen ABDR qualified F-15 assessors (4 crew chiefs, 2 fuel specialists, 4 electrical specialists, and 5 structural specialists) and fifteen ABDR assessors qualified on other aircraft (7 crew chiefs, 1 hydraulic specialist, 1 electrical specialist, and 9 structural specialists). All were qualified at skill level-7 in their specialties.

The subjects for the second experiment were eighteen qualified F-15 mechanics (10 crew chiefs and 8 structural specialists). The subjects included both 5-level and 7-level technicians.

ABDAR Data Collection Team Composition (Paper and ETI)

Based upon scheduling considerations and the variety of skills required, two data collection teams were formed to facilitate a two-shift operation.

a. Positions and Responsibilities. The requirements for the field test team with positions and responsibilities are provided below:

    1. *Field Test Director.* The field test director position was the focal point for the team. This individual understood the objectives, and the pitfalls, associated with doing the test. It was the responsibility of the field test director to ensure all personnel, equipment, subjects, and other requirements were available when needed. Also, the test director was responsible for ensuring consistency in the testing process throughout the field test.

    2. *Team Leader.* Two individuals filled the position of team leader due to multiple shift operations. The team leaders assisted the director in his efforts, were the focal point for each team, and monitored the day-to-day operations of the team. The team leader also fulfilled the Trainer-Briefer role. This included performing the in-briefing, training, and out-briefing of the subjects. Subjects required approximately two hours of training. The team leader also ensured that the subject understood what was desired when documenting the assessment, how to determine completion of ABDR, and the rules to be followed during the test.

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[1] The experimental design required that the number of observations in each cell be equal. Since one F-15 assessor was not able to complete the testing, it was necessary to drop one observation from each of the other cells to give the same number of observations per cell. The F-15 assessor who could not participate had been designated as subject #5 in the F-15 assessor group. To equalize the number of subjects per group, the data for subject #5 for each assessor group was dropped from the analysis.

(a) In-briefing of Subjects. The following are the areas that were discussed with the test subjects before the start of the test.

(1) An overview of the ABDAR technology effort.

(2) Work schedules.

(3) Rules of the test.

(4) Expectations of the subjects.

(5) Emergency telephone numbers and contacts.

(6) Consent form, provided by AFRL/HESR.

(7) Demographic information form (APPENDIX D).

(b) Out-briefing of Subjects. The following are the areas that were discussed with the test subjects before releasing them back to their owning organizations.

(1) Exit Questionnaire (APPENDIX E) for ETI subjects only.

(2) Confidentiality of test specifics.

(3) Appreciation for their effort.

3. *Test Monitor/SME*. The test monitors were responsible for monitoring the subjects performance and collecting all performance data. The test monitors also served as subject matter experts for the test.

(a) The SME's responsibilities included:

(1) Providing maintenance expertise on the tasks being accomplished on the aircraft.

(2) Extensive knowledge of the ABDAR Demonstration System and its technical data.

(3) Assisting the subject when help was required.

(4) Collecting data.

(5) Assisting in tool and equipment accountability.

(6) Identifying and documenting errors when they occurred during the session.

(7) Recording time measurements.

(8) Scoring the data collection sheets after each test.

(b) The SME's daily tasks included:

(1) Preparing the aircraft before the arrival of the subject.

(2) Acting as the Safety Officer.

(3) Calling time outs to recover the ABDAR Demonstration System when bugs occurred.

(c) Other roles the SME personnel fulfilled were the ABDAR team positions of Resource Manager, Pro Super, Engineer, ABDR Technician, and Team Chief. These individuals, familiar with the ABDR process and the ABDAR Demonstration System, were always available and provided consistent information and feedback to the assessor. Due to the large amount of interaction between this position and the assessor, in the electronic version, this function required full time attention.

(d) *Support Personnel.* The Support Personnel were only needed for the electronic portions of the field test. They were available for each shift and maintained the database, server, and PMA software. Additionally, support personnel provided support for the LAN and hardware.

Facilities

Figure 2 provides a graphical presentation of the layout of the hangar facility located at Robins AFB, GA. The use of an office, within sight of the planned aircraft parking location, was required. This office was used as the team headquarters, briefing and training facility, and housed the workstation and ABDAR Field Test server. The office had air-conditioning, electrical service, and telephone and base Local Area Network (LAN) hook-ups to support the workstation and ABDAR Field Test server. The office could be locked, providing a secure area for storage of PMAs, battery chargers, and other miscellaneous equipment and materials. The Radio Frequency (RF) LAN antenna was mounted on top of another office and in line of sight of the aircraft. Along with the dedicated aircraft and hangar space, the following items were provided for the subjects at the aircraft.

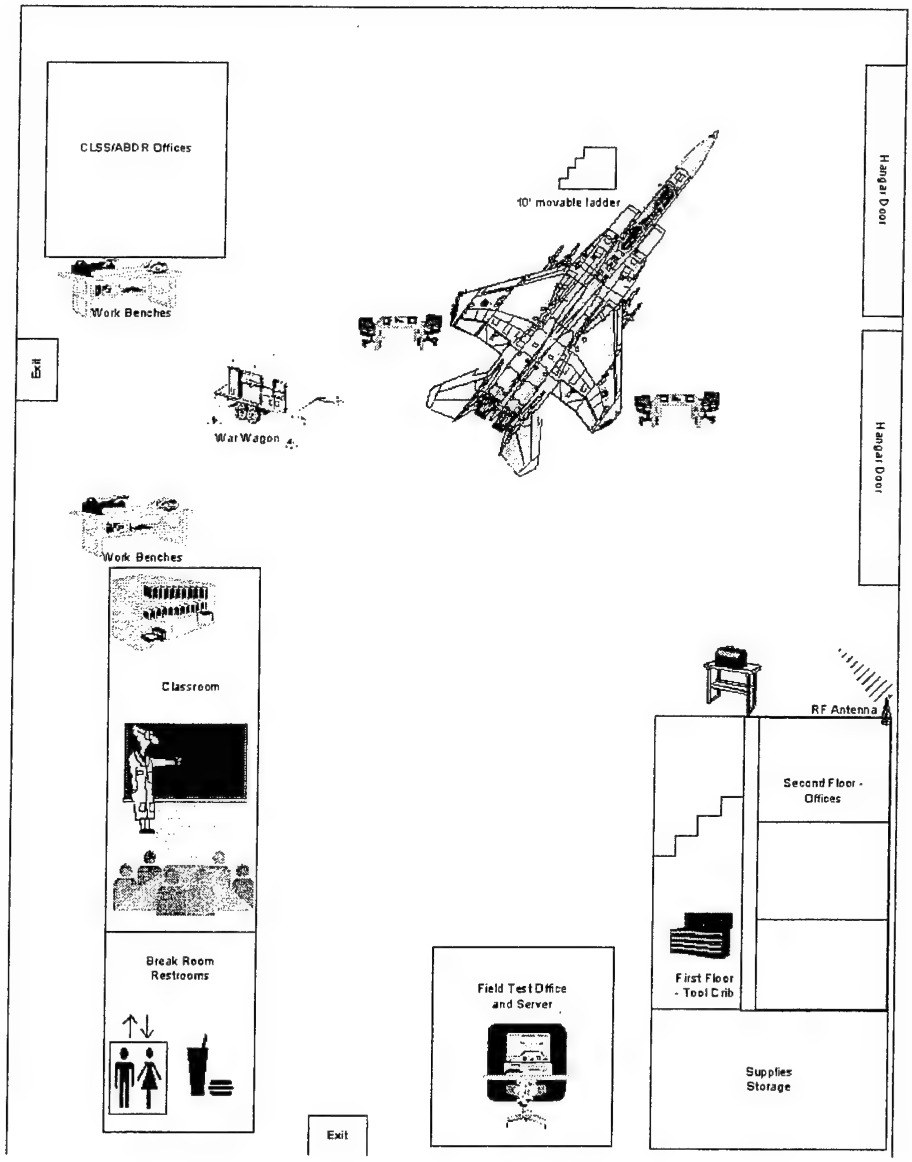

Figure 2 – Robins AFB Hangar Facility Layout

a. Worktable and chairs.

b. 10-foot ladder.

c. Assessor Tool Kit.

d. A TO library containing a sufficient selection of TOs to cover the damages for use by subjects performing the assessments using paper technical data and as a reference for the team members (paper technical order condition only).

Damage Information

In determining the areas of the aircraft that were to be damaged for the field test, three basic criteria were used.

a. *The damaged areas must include functional and structural components to be representative of most types of assessment performed in ABDR.* Therefore, areas were chosen that contained the following types of functional components: avionics, pneumatic, hydraulic, mechanical flight control, electrical, and wire bundles. This functional breakdown is identical to the breakdown found in the 1-1H-39 and AFTO Form 97. Additionally, the damaged areas were required to contain varied types of structural components. The damaged areas were to include all five categories of structural components and to represent both types of structural assessment (K-factor and class) used in ABDR on F-15s.

b. *The location and extent of the damages must be consistent with test constraints (time, safety, security, etc.).* The ease of conducting and administering the field test was taken into consideration when determining damage location. To maximize the use of the aircraft, it was prudent to damage areas of the aircraft that were not close to each other. To minimize the workload of the subjects, each damage must be able to be assessed during a single working session.

Damages must be representative of damages incurred during combat operations. The procedures for simulating battle-damage, as described in the 1-1H-39, were used to inflict damage on the test sites. The process produced damages that realistically simulate damages inflicted in combat.

Two damage sites were created. Each served as a separate test problem for the evaluation.

The damaged areas did not require use of classified data and did not create any major safety problems, other than height (approximately 7.6 ft. at wing tip). Concentrating on these areas enabled the testing of a wide range of functional assessments and minimized the need to develop large volumes of redundant technical data. The following areas were damaged for the field test.

a. **Door/Bay 6R in Zone 4.** This area contains 18 different functional components, 25 LRUs, approximately 30 wire bundles, and approximately 50 structural components. The functional systems included electrical, avionics, and miscellaneous (e.g., LOX and environmental cooling). The approximately 50 1F-15A-39-indexed Category I, II, IV, and V structures used the F-15 K-factor evaluation method for determining serviceability. The damage was inflicted using a pickaxe and screwdriver, simulating a close proximity explosion. The damage infliction process resulted in 14 damaged components.

b. **Left Wing Trailing edge in Zone 11**. This area included 6 Systems, 31 LRUs, 3 wire bundles, and approximately 65 structures. The functional systems included hydraulics, pneumatics, and mechanical flight controls. The structural

components were category I, II, and V, and used diameter and location as the evaluation method. The damage was inflicted using C4 explosives, simulating penetration of a projectile. The damage infliction process resulted in 8 damaged components.

Data Collection Sheet

The data collection sheets (APPENDIX F) were designed to help the data collector track and record information on the technician's performance. The sheets provided an outline of the task, identified specific subtasks, and provided places to record the start and stop times for each subtask. Cues and reminders were provided to help ensure the data collector did not overlook essential points or actions. The data collection sheet provided:

a. "Cheat sheet," type information for the monitors, organized to support ease of data collection.

b. Places to record start and stop times

c. Identification of which electronic documents would be needed for evaluation and analysis later.

d. A place to record which damages were found and which were pointed out to the subject.[2]

e. A place for documentation of any errors identified, along with documentation of the solution.

Field Test Rules

Test rules, APPENDIX G and APPENDIX H, were established for the subjects and all members of the test team. Subject rules were established so the subjects had a clear understanding of what was expected of them. The rules were briefed as part of the in-briefing and were available throughout the field test. Test Monitor rules provided the ground rules that were established for the monitors and other positions of the data collection team to ensure "consistent and equal treatment" of subjects throughout the field test.

[2] Damages that the subject did not find within a specified time were pointed out, so that the subject could plan/specify repairs for all damages. This was essential to ensure that all subjects developed planned repairs for the same set of damages.

Field Test Scenario (Paper and ETI's)

Since the primary focus of the ABDAR Demonstration System was to improve the speed, accuracy, and completeness of assessment, the field test targeted the assessment portion of the ABDR process. The assessment portion of the ABDR process consists of Damage Collection, Repair Selection, Repair Planning, and the Documentation associated with each of these processes. Each session started with a completed Debrief and ended with Selected Repairs planned for accomplishment. The need for interaction with Status Boards and Resource Management was based on the situation at any given time. Standard Monitor/SME responses were developed for all anticipated interactions and questions from the subjects, so that all requests and questions were handled identically. In those instances where the interaction was novel, the test monitor(s) created and provided logical answers on the spot. The created answers became part of the available set of interaction responses for use if the need arose again.

Test scenarios were performed on two damage sites and graded according to the criterion identified in

Evaluations and Scoring (page 15). Each damage site was treated as a separate test problem for analysis purposes.

Subjects using Paper received scenarios provided in APPENDIX I and APPENDIX J. Subjects using the electronic media received scenarios shown in APPENDIX K and APPENDIX L. The scenarios are identical except for the type of technical data used.

Field Test Data Collection Considerations

Test Problems

Two separate sections of the aircraft were damaged for the field test. Each damage site was treated as a separate problem. The Avionics Bay damage site had 14 damages. The Wing damage site had eight. A complete, accurate assessment, according to TO 1-1H-39, includes a detailed description of each damage and the chosen repair action. TO 1-1H-39 defines the minimum requirements for describing a damage and a repair.

As stated in TO 1-1H-39, each damage requires a clear and complete description to ensure that another assessor can pick up and continue the assessment, without having to reassess any damage(s). To meet this goal, the assessor must identify the entities that are damaged, give the exact location of the damage, and describe the extent of the damage. The specific –39 has an indexed graphic with a corresponding table of information about each entity. Information from this table is useful to describe the damage, its limits, and the actions to take for evaluation and repair of the damage.

Evaluations and Scoring

To assist in maintaining objectivity and accuracy, assessments were evaluated immediately after completion. The test monitors evaluated the assessment information documented by the subject using the criteria shown in APPENDIX M. A score was then assigned in accordance with APPENDIX N and APPENDIX O. The information collected by the test monitors was tabulated and attached to the evaluation data packet for analysis. The following areas were evaluated and scored.

a. Structure Damage Collection

b. System Damage Collection

c. Wiring Damage Collection

d. Repair Selection/Instructions

e. Repair Planning and Scheduling

f. Other Areas

(1) UXO Inspection and documentation

(2) Use and documentation of Engineering Input

(3) Estimated Times

(4) Highest Category and Class Documentation

(5) Number of Found Damages

FIELD TEST SCHEDULE

Ideally, it would have been preferable to completely randomize the presentation of the three types of media, however, real-world commitments and schedules did not permit this approach. Therefore, the decision was made to run subjects using Paper media in the first three-week experimental block, subjects using CDM in the second, and subjects using IPDF in the third. Subjects in the Paper media condition were run in the fall of 1998 and subjects using the CDM and IPDF media were run in the fall of 1999. The following assumptions were made when creating the field test schedule:

a. Estimated six hours per session.

b. Only one active session at a time.

c. One Monitor/SME would observe a subject as the subject performed the assessment task. Monitor/SMEs would be allowed to switch within a session or between sessions.

d. In-brief, training, and out-brief accomplished by someone other than the test monitor (team leader).

e. Two data collection shifts per day.

The field test period was divided into three three-week testing blocks. This breakout supported 54 subjects, which equates to 18 subjects per media variable. With six subjects per week, each three-week block supported 18 subjects. See APPENDIX C – FIELD TEST SCHEDULE, Table C- 1 – Paper Schedule, Table C- 2 – Electronic One Schedule, and Table C- 3 – Electronic Two Schedule.

Each subject accomplished the required training prior to the first session. The subjects then participated in two experimental sessions, followed by an out-briefing at the end of the last session. The schedule required two full days of a subject's time. This did not include travel time for those subjects that were assigned on temporary duty (TDY) to the test site. On the first day, the subjects trained and participated in the first experimental session. The second day the subjects completed the second experimental session and the out-brief from the experiment.

TRAINING CONSIDERATIONS

Training issues for the ABDAR field test centered on the training of the data collection team and the training of the subjects. Subjects received equivalent training, regardless of the media type being used. Training of the data collection teams was designed and validated during the Pre-Field Test.

Subjects

All subjects, regardless of the media condition used (Paper, IPDF, or CDM), received training before the ABDAR field test. Subjects trained only on the media that they used during the field test. Training allowed the subjects to become familiar with the media condition they would be using.

Tutorials were developed for subjects in the CDM and IPDF conditions. Subjects in the paper condition used the tutorials contained in TO 1-1H-39 and TO 1F-15A-39. Subjects trained themselves on ABDR using their designated media as the training technique. The subjects in the Paper media condition used the TO 1-1H-39 tutorial and other technical manuals to teach themselves ABDR. The subjects in the IPDF media condition trained themselves in ABDR using the paper tutorial and the ABDAR Demonstration System. The paper tutorial provided instructions on how to find the required information on the computer and provided opportunities to practice data retrieval on the system. The subjects using the CDM media trained themselves on the

ABDAR Demonstration System with a similar paper tutorial, which presented the basic procedures for using the electronic CDM version.

In all conditions, the Trainer-Briefer was present to assist the subject and answer questions. The goals of the self-paced training sessions were provided to the subjects as a self-measuring device. To successfully complete the training, the subject must be able to:

a. Use the media to locate and evaluate a damage.

b. Use the media to identify repair options.

c. Document a damage assessment according to specifications established by TO 1-1H-39.

d. Identify, acquire, and evaluate real time information needed to make repair decisions.

e. Plan repairs making effective use of time and resources.

Data Collection Team Position Training

Position Training took place during the Pre-Field Test. Training for the test monitors included directions for documenting the data collection sheets, preparation of the aircraft before each session, interfacing with the test subject, and safety considerations. Training for the team leaders included how to in-brief, out-brief, use the training materials, scheduling and coordinating subjects, and general management of the field test.

RESULTS OF THE ABDAR FIELD TEST

The data for each of the main dependent variables were subjected to an Analysis of Variance (ANOVA) test. Data for the two testing sessions (damage site one and damage site two) were combined to provide a single score on each subject on each measure (Time, Accuracy, and Completeness). The ANOVA's for Time, Completeness, and Accuracy were planned a priori. Additional post hoc testing was performed according to trends in the data. If an ANOVA was significant for a variable, a Bonferroni Multiple Comparison test was used to determine statistical significance of differences between the means. For example, the ANOVA for Time was significant for the independent variable of Media. Therefore, there was a difference between the mean scores for the fastest variable (subjects using CDM) and the slowest variable (subjects using IPDF). The ANOVA does not supply any information about relationships with the intermediate variable (subjects using Paper). The Bonferroni Multiple Comparison Test allowed determination of significance between any two of the means.

The Time variable was comprised of the amount of time a subject took to complete the assessment, including identification of damage, evaluation of damage and repair planning. The monitors recorded (in minutes) the time that each subject worked on the assessment task, not including breaks and time outs for unavoidable interruptions (such as, system malfunctions).

The Completeness and Accuracy Variables were derived from the "perfect assessment", developed before the field test and data collection. To develop the "perfect assessment" three highly experienced ABDR assessors were employed. Each assessor was also an experienced instructor, adding to the credibility and expertise of the three. Each assessor performed the assessment individually. As was expected, the three assessments differed. The test monitors then lead the assessors back through all of the assessments, pointing out discrepancies. From this exercise, the three assessors came to a consensus, a "perfect assessment" which was used as the standard for grading the Accuracy and Completeness variables.

The Completeness Variable reflected the thoroughness of an assessment. If the perfect assessment had 100 documentation requirements annotated and the experimental assessment had 76 documentation requirements annotated, the assessment would receive a score of 76% complete (76 annotated/100 total).

The Accuracy Variable reflected how many documentation requirements were annotated correctly in an experimental assessment. To continue the example from above, suppose that of the 76 documentation requirements annotated, only 56 were annotated identically to the perfect assessment. In this case, the experimental assessment would receive a score of 56% Accurate (56 correct annotations/ 100 total). Why not a score of 74% Accurate (56 accurately annotated/76 annotated)? It was decided that only considering the accuracy of those damages that were annotated was not as precise a measure as the accuracy of all possible documentation requirements. When determining accuracy, using only the annotated documentation requirements, instead of the documentation requirements from the perfect assessment, is more reflective of the completeness of an assessment than the accuracy. Simply put, if a documentation requirement was missed during assessment, it was not accurately assessed.

Statistical Analysis

Results of the statistical analysis for each variable are provided in the following paragraphs.

<u>Time</u>

The ANOVA for the dependent variable of Time (Table 2) showed a significant effect of Media, $F\,(2,29) = 15.58$, $p < .0000$. Assessors using CDM performed quickest ($\bar{x}$ = 337.6 minutes), followed by assessors using Paper ($\bar{x}$ = 447.9), and assessors using IPDF ($\bar{x}$ = 629.6). Bonferroni Multiple Comparison tests show significant

differences between the means of subjects using CDM and subjects using IPDF and between the means of subjects using Paper and subjects using CDM.

Table 2 – Analysis of Variance Table – Time

Source		Sum of	Mean		Prob
Term	**DF**	**Squares**	**Square**	**F-Ratio**	**Level**
A: Assessor	1	32.03333	32.03333	0.00	0.962186
B: Media	2	434816.6	217408.3	15.58	0.000046*
AB	2	22821.27	11410.63	0.82	0.453426
S	24	334962.4	13956.77		
Total (Adjusted)	29	792632.3			
Total	30				
*Term significant at alpha = 0.05					

There was no significant effect for Technician Type, nor was there an interaction between Technician Type and Media.

Completeness

The ANOVA for the dependent variable of Completeness (Table 3) showed a significant effect of Media, F (2,29) = 82.47, p < .0000. Assessors using CDM completed 95.4%, IPDF Assessors completed 90.3%, and Assessors using Paper completed 56.8% of the perfect assessment. A Bonferroni Multiple Comparison Test showed assessors using CDM and IPDF completed significantly more of the perfect assessment than subjects using Paper. There was not a significant difference between subjects using CDM and IPDF.

Table 3 – Analysis of Variance Table – Completeness

Source		Sum of	Mean		Prob
Term	**DF**	**Squares**	**Square**	**F-Ratio**	**Level**
A: Assessor	1	197.6333	197.6333	3.71	0.066121
B: Media	2	8794.066	4397.033	82.47	0.000000**
AB	2	36.86666	18.43333	0.35	0.711168
S	23	1279.6	53.31667		
Total (Adjusted)	29	10308.17			
Total	30				
*Term significant at alpha = 0.05					

There was no significant effect for Technician Type. There was no interaction between Technician Type and Media

Accuracy

The ANOVA for the dependent variable of Accuracy (Table 4) showed a significant effect of Media, F (2,29) = 40.08. p < .0000. Assessors using CDM achieved an accuracy rate of 90.9%, Assessors using IPDF were 83.3% accurate, and Assessors using Paper were only 39.8% accurate. A Bonferroni Multiple Comparison Test showed assessors using CDM and IPDF to be significantly more accurate than assessors using Paper. There was not a significant difference between assessors using CDM and IPDF.

Table 4 – Analysis of Variance Table – Accuracy

Source Term	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level
A: Assessor	1	282.1333	282.1333	3.94	0.0586
B: Media	2	15204.07	7602.033	106.25	0.000000*
AB	2	59.26667	29.63333	0.41	0.665527
S	23	1717.2	71.55		
Total (Adjusted)	29	17262.67			
Total	30				
*Term significant at alpha = 0.05					

There was no significant effect for Technician Type. There was no interaction between Technician Type and Media.

Interpretation of Test Results

A major factor impacting the analysis of the ABDAR field test data is the limited number of subjects. Due to the limited subject pool, the extensive time required to collect data for each subject, and scheduling issues, only five subjects participated in any one condition of the main study. This factor alone had the greatest impact on analyzing the data. The combination of limited subjects and a complex and time-consuming task resulted in very wide performance variances within a condition. The consequence of the wide variances is a lack of precision in the results. The wide range of performance times limits the identification of statistically significant effects to only large effects, such as the speed difference between subjects using CDM and IPDF.

Findings for each of the dependent variables: Time, Completeness, and Accuracy are discussed and interpreted in the following paragraphs.

Time

Subjects in Experiment One using CDM performed the assessment faster than subjects using the other two media types. Assessors using CDM finished nearly two hours sooner, on average, than their counterparts using Paper, and more than five hours faster than the subjects using IPDF. As mentioned previously, the large standard deviation associated with the subjects using Paper, almost 2.5 hours (149.86 minutes), prevents any statistical tests from identifying a potential difference between subjects using CDM and Paper. However, subjects using Paper performed, on average, 181.7 minutes quicker than subjects using IPDF. Even with the large standard deviations experienced under both media conditions, the three-hour difference is statistically significant. The five-hour difference between subjects using CDM and IPDF was also significant, according to the Bonferroni Multiple Comparison Test. See Table 5 for Time means, standard deviations, and ranges for all conditions for the F-15 assessors and other aircraft assessors.

Table 5 – Mean Time (in minutes) for Assessment of Both Damage Sites

	CDM	IPDF	Paper
Mean	337.60	629.60	447.90
Std. Dev.	43.90	123.99	149.86
Range	141	369	412

There is very little clarity in the Time data. Figure 3 shows the problem with the Time data, namely, it has too wide of a range to permit many inferences. The performances of subjects using CDM are obviously superior to subjects using IPDF because there is only a three-minute overlap in their respective ranges. On the other hand, the range of times for the subjects using Paper is so wide that it nearly encompasses the full ranges of both of the other two media types. Due to the excessive range and huge variability associated with the Time variable, particularly with the subjects using Paper, it is difficult to draw firm conclusions from the time data without consideration of the impact of time on the variables of completeness and accuracy. The Time data should be viewed only in context with the other dependent variables. A fast assessment time is moot if the assessor only completes 50% of the task. A short assessment time is only relevant if the assessment is also accurate and complete.

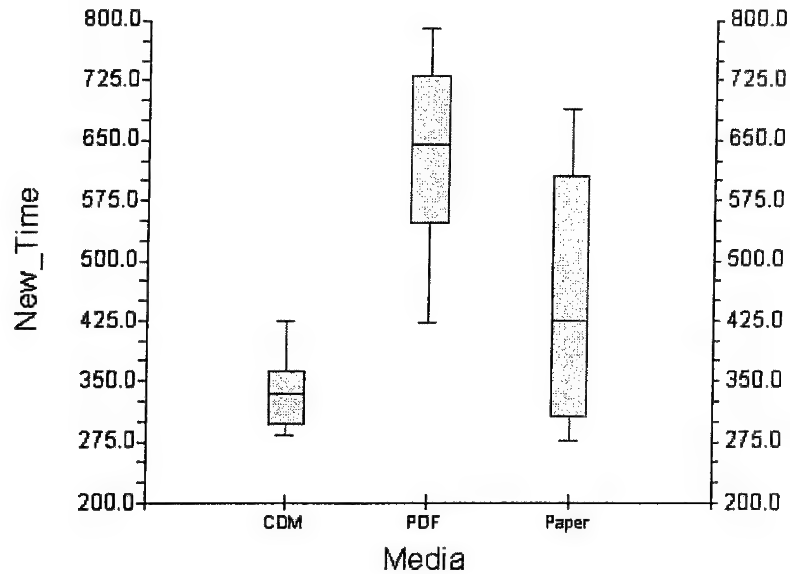

Figure 3 – Box Plot for Time Data

(NOTE: The graph shows the median, inter-quartile range, and adjacent values for each of the media types for the dependent variable of Time.)

It should be noted that subjects using the IPDF media type always showed improvement in damage assessment time between the first and second damage site. This implies a strong learning curve associated with the IPDF. This has ramifications for the interpretation of the time data. More training with IPDF or simply more experience will reduce the time taken to perform an assessment.

There are several possible explanations for technicians using IPDF data taking so much longer to perform the assessment task than technicians using the paper TO. The most plausible explanation is that the ABDAR Demonstration System provides a structure and aids that guide the technician systematically through the process, ensuring accuracy and completeness, while the technician using the paper TO is left on his own. In other words, the ABDAR IPDF system forces the technician to follow a structured process that insures a more complete assessment. The technician using paper does not have this forced structure and, consequently, is more likely to miss important information. This may help to explain the wide range of scores for the paper condition. The technician using Paper who by nature is thorough and complete in his work may have taken much longer to complete the assessment, while the technician who tends to be less thorough took much less time. This interpretation is supported by the fact that there is a high correlation (r=.88) between the Time and Completeness scores for the technicians using paper, (compared to r=.46 for IPDF and .51 for CDM).

Completeness

The Completeness of an assessment is the measure of how thoroughly the assessor annotated the documentation requirements. The documentation did not need to be annotated exactly as described in the perfect assessment, so long as it was recorded and the information was correct.

The Completeness data is more robust than the Time data and allows a more precise analysis. As with the Time variable, the only significant Main Effect was found for the Media variable. In this case, assessors using CDM and IPDF performed significantly better than the assessors using Paper. In fact, assessors using CDM and IPDF performed so well that it is possible the task was not difficult enough to discern any difference between subjects using the two media types (Figure 4). Subjects using the CDM and IPDF media types performed above the 90% complete level ($\bar{x}$ = 95.4 and 90.3, respectively). A more complex task might reveal a performance difference between these two media types. See Table 6 for means, standard deviations, and ranges for all conditions. Figure 4 provides a box plot for the completeness scores.

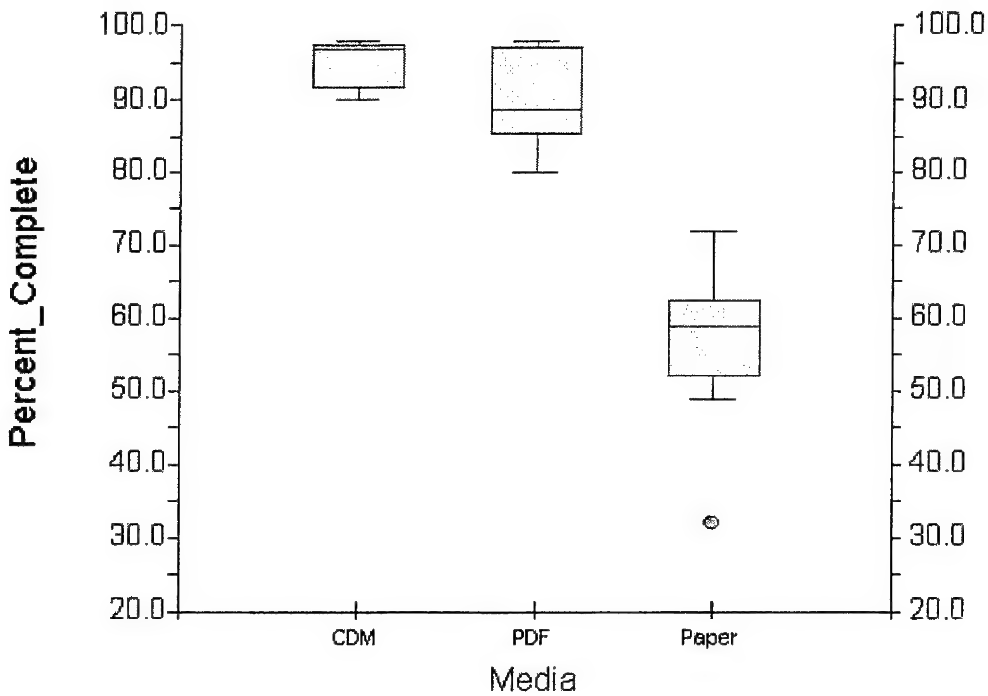

Figure 4 – Box Plot for Completeness

(NOTE: The graph shows the median, inter-quartile range, and adjacent values for each of the media types for the dependent variable of Time.)

Table 6 – Descriptive Statistics for Percent Complete

	CDM	IPDF	Paper
Mean	95.40	90.30	56.80
Std. Dev.	3.10	6.34	10.88
Range	8	18	40

The Paper media shows a real weakness on this measure of effectiveness. Subjects using Paper annotated only 56.8% of the documentation requirements that were identified in the perfect assessment. This suggests that, for assessments performed using paper TOs, on average almost one-half of all documentation requirements will not even be recorded in the initial assessment. As a result, additional repairs and documentation requirements will be identified during the repair process. This is not due to any assessor shortcomings; it is because of the complexity and tediousness of using the paper TOs. Assessors using CDM and IPDF performed much higher scores on this measure. On average, assessors using the CDM or IPDF media types, along with the ABDAR Demonstration System, will miss *less* than 10% of documentation requirements. Clearly, the electronic technical data, in conjunction with the ABDAR Demonstration System, is a tremendous aid to skilled assessors performing ABDR assessment tasks.

Accuracy

The Accuracy of an assessment is the measure of how accurate the assessor was at annotating documentation requirements and the correctness with which the annotations were assessed. This is the most critical measure of effectiveness for an assessment.

An assessment can be done quickly but poorly (incomplete and inaccurate). An assessment can be thorough, with most documentation requirements being annotated, but not annotated accurately. Either of these conditions can lead to an inadequate assessment and additional work for technicians making repairs to the aircraft. An accurate assessment provides the greatest opportunity for an aircraft to be repaired to provide the needed capabilities.

As with the completeness measure, assessors using CDM and IPDF far outperformed assessors using Paper. Figure 5 clearly shows the performance advantages provided by subjects using CDM and IPDF. Assessors using Paper achieved an Accuracy level of 40% while assessors using CDM and IPDF performed at 91% and 83%, respectively. Such a large margin of difference between subjects using the Paper media and subjects using the other media types demonstrates the advantages of the ABDAR Demonstration System in an overwhelming manner. See Table 7 for means, standard deviations, and ranges for all conditions.

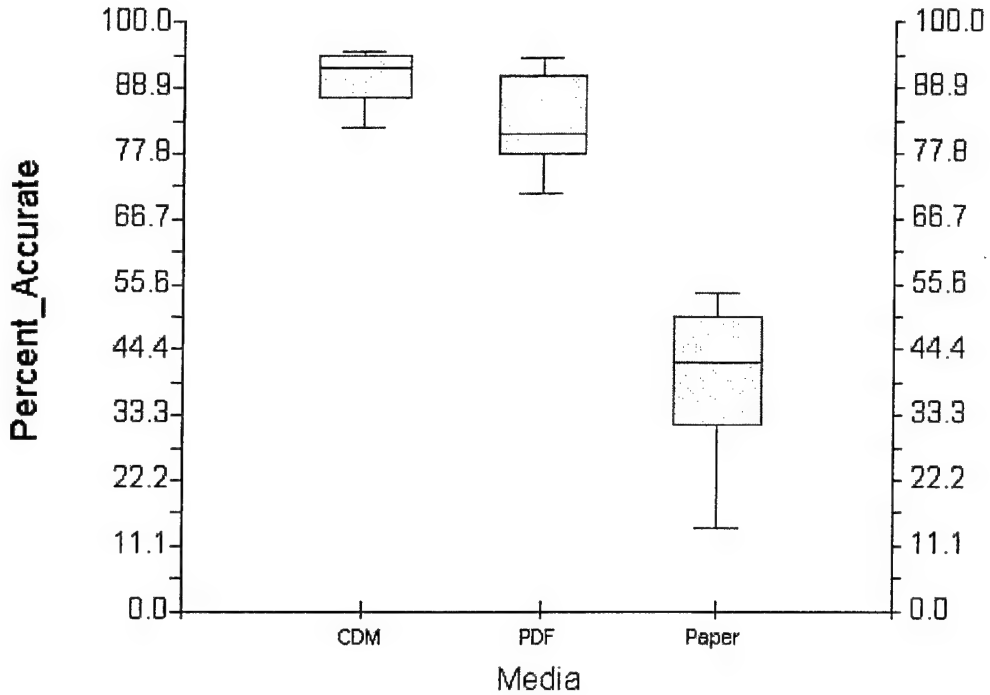

Figure 5 – Box Plot for Accuracy

(NOTE: The graph shows the median, inter-quartile range, and adjacent values for each of the media types for the dependent variable of Time.)

Table 7 – Description Statistics for Percent Accurate

	CDM	IPDF	Paper
Mean	90.90	83.30	39.80
Std. Dev.	4.43	7.83	12.15
Range	13	23	40

Resolution of Hypotheses

The following paragraphs provide resolution for each of the hypotheses outlined in the field test Objectives on page 6. For convenience, the objectives have been restated, in italicized text, with the resolution following:

a. *The F-15 Assessor using CDM data with ABDAR will perform significantly better (fewer errors, less time, more complete assessment) than the F-15 Assessor using Paper.* This hypothesis was unequivocally supported, F-15 Assessors using CDM performed the assessment in less time ($\bar{x}$ = 338.2 vs. $\bar{x}$ = 479.8), more completely ($\bar{x}$ = 96.4 vs. $\bar{x}$ = 60.2), and more accurately ($\bar{x}$ = 92.0 vs. $\bar{x}$ = 43.6) than F-15 Assessors using Paper.

b. *The Other Assessor using CDM data with ABDAR will perform significantly better (fewer errors, less time, more complete assessment) than the F-15 Assessor using paper.* This hypothesis was confirmed with the same data as hypothesis number 1 because no significant differences between Assessor types existed Other Assessors using CDM performed the assessment in less time ($\bar{x}$ = 337.0 vs. $\bar{x}$ = 479.8), with more thoroughness ($\bar{x}$ = 94.4 vs. $\bar{x}$ = 60.2), and more accurately ($\bar{x}$ = 89.8 vs. $\bar{x}$ = 43.6) than F-15 Assessors using Paper

c. *There will be a significant performance difference (fewer errors, less time, more complete assessment) among technicians when using CDM data with ABDAR.* There were no significant differences between F-15 Assessors and Other Assessors on any of the three dependent variables.

d. *There will be a significant performance difference (fewer errors, less time, more complete assessment) among technicians when using IPDF with ABDAR.* There were no significant differences between F-15 Assessors and Other Assessors on any of the three dependent variables.

e. *The F-15 Assessor will perform significantly better (fewer errors, less time, more complete assessment) using CDM data with ABDAR than when using IPDF data with ABDAR.* The F-15 Assessor using CDM data with ABDAR Demonstration System performed the assessment in significantly less time than the F-15 Assessor using IPDF ($\bar{x}$ = 338.2 vs. $\bar{x}$ = 594.0). There were no significant differences for the completeness and accuracy variables.

f. *There will be a significant interaction between technician type and media on both errors and time. CDM data with ABDAR will tend to minimize the differences between technician types while the Paper media with ABDAR will show large differences between technician types. The interaction will be ordinal in nature, meaning the relative ranking of the technician types will remain the same at all three levels of media.* There were no significant interactions for any of the dependent variables.

Exit Questionnaire Comments Summary

Of the 36 subjects who participated in the electronic portion of the ABDAR field test, two did not fill out the exit questionnaire. The remaining 34 subjects, provided answers to all four exit questionnaire questions. The comments by the subjects provided on the exit questionnaire were generally quite positive. Some system weaknesses were noted and several suggestions made for improving the system. Several subjects expressed a desire to see the system implemented for operational use. The following paragraphs provide the questions and some typical responses to those questions. APPENDIX P provides a complete list of the actual written comments given by the subjects.

Question 1. *What aspects of the ABDAR System were most helpful to you in performing your job?* Typical responses:

> "I like how it takes care of filling out the AFTO 97's. Really like the way it takes you to the specific TO area you need to be in, links are very useful."
>
> "The speed in which it performs the task. The way the screen won't switch over unless you process the work correctly."
>
> "K-factors automatically figured for you. No research required with this system. Extremely quick ordering."
>
> "TO's being in the computer, reduces a lot of time looking through books."

Question 2. *What aspects of the ABDAR System did you dislike?* Typical Responses:

> "Not having detailed parts (information), i.e., fittings had no sizes that were recognizable at a glance."
>
> "Really none, just takes time to get used to the system."
>
> "System slowed to a crawl or even locked up after a few hours of use. I realize that the system is still under design."
>
> "When a qty of 60 for fasteners is needed, then when you allocate you should not need to allocate 60 times for 60 fasteners. A block needs to be added for any deviations and work stoppage."

Question 3. *And are there any changes you would like to see made to the ABDAR System?* Typical responses:

> "Sensor touch screens in which you can use a pointer."
>
> "Maybe, install a track ball type mouse."
>
> "Better user friendly controls with voice and video links (if possible)."

Question 4. *Are there any other concerns or comments that you would like to be known?* Typical responses:

> "Make one system and improve on that system. TO's should be all standardized. Not fighters, bomber, airlift, i.e., if 27 is for flight controls then it should be for each weapon system."
>
> "I personally need more training to give a better viewpoint on what we really need. Overall it is a vast improvement over having to physically search for info and manually document forms."
>
> "I think it is an excellent program. I think it should be helpful to the assessors who understand the setup and material."
>
> "Make it so! In other words make it happen as soon as possible. "

Table 8 provides a summary of the responses by question number, whether the response was positive or negative, and the category of the answers. Also, one answer can relate to more than one category.

Table 8 – Exit Questionnaire Summary

	Question 1		Question 2		Question 3		Question 4	
	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Totals by Answer/Comment	34	0	12	22	9	25	31	3
AF Infrastructure								1
Communication	1							
Data				4			1	
Decision Making	1					2		
Documentation	4						1	
Field Test Team							2	
General	11		11	1	9	2	24	
Hardware				3		3		1
High Tech						2		
K-factors	2							
Known Problems				8		2		
Part Ordering	3						1	
Planning	1			1		4		
System Design			1	7		12	1	
TO Research	2							
Usability	5			1		1	1	1
View of Data						3	2	1
Wiring	2							
Wizards	4		1					
Total by category	36	0	13	25	9	31	33	4

DISCUSSION

The ABDAR Demonstration System was tested in a simulated ABDR environment and demonstrated improvements in speed, accuracy, and completeness over the current ABDR process. Unequivocally, assessors using either CDM or IPDF media types far outperform assessors using Paper. The only advantage assessors using Paper have is a slight improvement in time over assessors using IPDF. However, due to the lack of completeness and accuracy of the assessments by subjects using Paper, the time advantage becomes irrelevant. In other words, because the assessments were not as complete and accurate, it made little difference how quickly they were performed. It is likely that any time advantages gained through paper assessments are lost when the repair process is initiated and the repair technicians must compensate for incomplete information provided during the assessment.

Curiously, there was no statistical difference between the performances of F-15 assessors and other assessors on any of the measures of effectiveness. Although, for both completeness and accuracy, the differences observed approached significance. The ANOVA's on completeness and accuracy returned probability values of .066 and .059 for the Assessor variable (F-15 Assessor vs. Other Assessor). In both cases, F-15 Assessors were more complete and more accurate. It is possible that collecting more data would have revealed a significant performance advantage for the F-15 Assessors, as would be expected for the assessment of an F-15. The ANOVA's did not indicate any interactions between assessor type and media type. The advantages and disadvantages of the media types were consistent for both categories of assessors.

Initially the ABDAR field test plan provided for comparing performance data from 7-level F-15 mechanics (crew chiefs and sheet metal specialists) with the performance of the F-15 and other aircraft assessors. However, since there were insufficient F-15 mechanics available for the field test (forcing substitution of 4-levels), it was necessary to drop the F-15 mechanic data from the analysis. Since the F-15 data was collected and analyzed (Appendix A), an informal comparison is still possible. Examination of the data provided in the appendix indicates a very similar performance pattern for all three variables. Times with CDM and paper were significantly faster than with IPDF, with no significant differences between performance times for CDM and paper. Completion and accuracy scores for CDM and IPDF were significantly higher than scores for paper. There were no significant differences in the completeness and accuracy scores for CDM and IPDF. An informal comparison with the data for the F-15 and other aircraft suggests that there was little practical difference in their performance and the performance of the F-15 mechanics.

The implication is that in the event that a battle damage assessment is required and a qualified F-15 or other aircraft assessor is not available, an F-15 mechanic can effectively perform the assessment using the ABDAR system. This could be an important advantage in a combat situation in which a damaged aircraft is forced to land at a base with no qualified assessors available.

Analysis of the field test results raised the question of whether the advantages observed for the IPDF data were due to the tools/aids provided by the ABDAR system or simply due to the fact that they were presented electronically. Specifically, were the beneficial results found for the IPDF data due to the enhancements (e.g., additional links,) made to the data and the aids (e.g., wizards) provided by the ABDAR system, or were they due to the presenting the information electronically? To provide some data relevant to this issue, a data collection team returned to Robins AFB to collect data from a new sample of F-15 Assessors. An additional data collection period was established to provide a tentative answer to this question. Six F-15 Assessors performed the assessment task under the same test and evaluation conditions and rules. For this test, subjects performed a conventional assessment with the use of Joint Computer-aided Acquisition and Logistics Support (JCALS) standard IPDF TOs instead of paper TOs. The JCALS IPDF data was presented electronically with no additional enhancements or aids. This setup allowed collection of data that would be comparable to the ABDAR enhanced IPDF data and the paper data collected during the field test.

The results of this supplemental data collection effort are provided in Appendix B. The time, completeness, and accuracy data were consistent with data collected in the main part of the study. No significant differences in mean times were found for any of the three media. The mean times were ABDAR IPDF - 594 minutes, JCALS IPDF - 486 minutes, and Paper – 526. For the completeness measure, subjects using IPDF scored significantly higher than both subjects using JCALS IPDF and subjects using paper. Subjects using JCALS IPDF scored significantly higher than subjects using Paper. The means were ABDAR IPDF - 93.8%, JCALS IPDF - 74.4%, Paper – 60%. The data for accuracy followed a similar pattern. The mean scores were ABDAR IPDF - 88%, JCALS IPDF - 58, and Paper - 44%. ABDAR IPDF subjects performed significantly better on the accuracy measure than subjects using either JCALS IPDF or Paper. There were no significant differences for the JCALS IPDF and Paper conditions.

As would be expected, the JCALS IPDF data demonstrates an improvement in performance times over paper resulting from easier access to data and elimination of the need to physically search for and acquire the data. Improvements are also observed for the Completeness variable. The reasons for this improvement are not obvious, but may be due to a greater reliance on the use of technical data, since it was more readily available.

Rapid assessment of a battle damaged aircraft is important, however, it is more important that the assessments be complete and accurate. Comparison of the field test data for the different types of media leads to some interesting observations. Figure 6 presents a plot of the Time data vs Accuracy Data for the four media types. The figure illustrates the relationship between three factors, time, completeness, and cost (where CDM has the highest cost, followed by ABDAR IPDF, JCALS IPDF, and Paper). The best performances in terms of accuracy are provided by the most expensive types of data, CDM and ABDAR IPDF. The less expensive paper technical and JCALS IPDF data were much less effective for supporting the ABDR assessment task

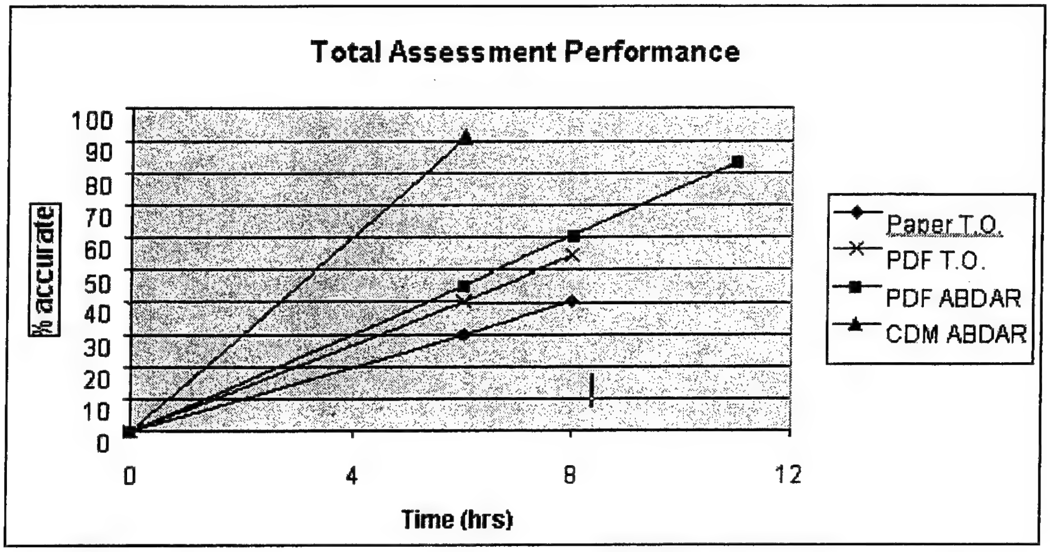

Figure 6 – Plot of Time vs. Accuracy for four Media Types

The CDM based data gives the best overall performance, but is generally more expensive. For new weapon systems, which will already have their technical data in the CDM format, the cost of adding ABDAR capabilities will not be great. However, to create CDM data for weapon systems (such as the F-15) would be cost prohibitive, since it requires completely reformatting and restructuring the technical data. For these weapon systems, the development of ABDAR IPDF would be the most cost effective solution. The addition of performance aids and enhancement of the existing JCALS IPDF data would be relatively inexpensive and would provide major improvements in performance.

RECOMMENDATIONS

The following section contains the recommendations of the ABDAR Integrated Process Team (IPT). Each recommendation is clearly identified and is preceded by supporting arguments.

The performance advantages experienced by assessors using the ABDAR Demonstration System with the CDM and IPDF media types demonstrate the advantages that would be realized if software of this nature were implemented. Assessors using the ABDAR Demonstration System with CDM data outperformed assessors using Paper on every performance measure by statistically significant margins. There is no doubt that using CDM data with the ABDAR Demonstration System is a radical improvement in ABDR methodology compared to using Paper. Assessors using the IPDF data with the ABDAR Demonstration System performed significantly better than those using Paper on performance measures of accuracy and completeness. Although the assessments using paper were faster, the benefits of faster assessments do not compensate for the lesser quality of the assessments.

Recommendation One: The ABDAR Demonstration System should be implemented for support of USAF ABDR operations.

The single performance flaw regarding the ABDAR Demonstration System is the performance time of assessors using IPDF. Several options exist to improve assessment times for individuals using IPDF. One constraint imposed on the ABDAR program was to limit the modifications made to the IPDF files. Allowing IPDF files to be enhanced should improve the speed of assessors using the IPDF files. Also, the IPDF user interface is not easily learned. This limitation could be overcome with addition of additional features to make it easier to use. The observation that in most cases the performances on the second damage site were quicker, suggests that more practice and training would reduce the times required to perform assessments using the IPDF data.

Recommendation Two: Efforts should be made to improve the speed with which assessors use IPDF media with the ABDAR Demonstration System. Improving the IPDF data type, by linking, and the improving the IPDF user-interface should reduce the time expended performing ABDR with IPDF.

The ABDAR Demonstration System using CDM data is the most effective tool for performing the ABDR assessment task. This combination provides the most accurate, most complete, and fastest assessment times. CDM media is the data type that provides the most robust capability.

Recommendation Three: An ABDAR system using CDM data should be provided for all future weapon systems. An ABDAR system using IPDF data should be provided for all legacy aircraft systems.

Implementation of the above recommendations will significantly enhance the Air Force ABDR program. The course has been laid out to develop a process (ABDAR Demonstration System) and data types (CDM and IPDF) that optimize the assessment of battle-damaged aircraft. The primary goals of the ABDAR Demonstration System were to improve the speed, accuracy, and completeness of ABDR activities. Following the recommendations of this test report will allow the goals of the ABDAR Demonstration System to become the reality of the ABDR Program Office, AFMC, and other functional managers.

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APPENDIX A – F-15 MECHANIC DATA

The F-15 Mechanic data is considered supplementary to the data presented in the field test report. Not all of the F-15 Mechanics meet the minimum subject requirement of being 7-level qualified. The difference in experience between 5 and 7-levels was deemed to be significant and, therefore, the F-15 Mechanic data was be analyzed separately so as not to contaminate the field test data.

Analysis of the F-15 Mechanic data paralleled the analysis of the other data. Three dependent variables of Time, Completeness, and Accuracy were measured. The data from each variable were submitted to a One-Way ANOVA, the results of which are presented below.

The results of each of the ANOVA's, for the F-15 Mechanic data, are analogous to the results from the field test. Each variable showed a significant effect of Media. The F-15 Mechanics Time variable data (See Table A-1) were fastest when using CDM ($\bar{x}$ = 288.0), followed by those using Paper ($\bar{x}$ = 389.8) and then those using IPDF ($\bar{x}$ = 580.3). As with the Assessor data, Bonferroni Multiple Comparison tests showed significant differences between subjects using CDM and subjects using IPDF; and between subjects using Paper and subjects using IPDF. There was no statistical difference between subjects using Paper and subjects using CDM.

Table A- 1 – Analysis of Variance Table – Time

Source		**Sum of**	**Mean**		**Prob**
Term	**DF**	**Squares**	**Square**	**F-Ratio**	**Level**
A: Media	2	264238.1	132119.1	16.65	0.000155*
S	15	119026.2	7935.078		
Total (Adjusted)	17	383264.3			
Total	18				
*Term significant at alpha = 0.05					

The F-15 Mechanics Completeness variable data (See Table A-2) was consistent with the Assessor data. Subjects using CDM and IPDF performed significantly more complete assessments ($\bar{x}$ = 95.0 and $\bar{x}$ = 92.8, respectively) than subjects using Paper ($\bar{x}$ = 55.2).

Table A- 2 – Analysis of Variance Table – Completeness

Source		**Sum of**	**Mean**		**Prob**
Term	**DF**	**Squares**	**Square**	**F-Ratio**	**Level**
A: Media	2	6020.333	3010.167	103.64	0.000000*
S	15	435.6667	29.04445		
Total (Adjusted)	17	6456			
Total	18				
*Term significant at alpha = 0.05					

The F-15 Mechanics Accuracy variable (See Table A-3) was also consistent with the Assessor data. Subjects using CDM and IPDF performed significantly more accurate assessments ($\bar{x}$ = 92.6 and $\bar{x}$ = 86.5, respectively) than subjects using Paper ($\bar{x}$ = 33.7).

Table A- 3 – Analysis of Variance Table – Accuracy

Source		**Sum of**	**Mean**		**Prob**
Term	**DF**	**Squares**	**Square**	**F-Ratio**	**Level**
A: Media	2	12620.78	6310.389	187.01	0.000000*
S	15	506.1667	33.74445		
Total (Adjusted)	17	13126.94			
Total	18				
*Term significant at alpha = 0.05					

APPENDIX B – SUPPLEMENTAL DATA

The original program plan provided only for comparing three types of data, CDM based, IPDF based and conventional paper TOs. However, analysis of the field test results suggested an additional question, which required addressing. Were the beneficial results found for the IPDF data due to the enhancements (e.g., additional links,) made to the data and the aids (e.g., wizards) provided by the ABDAR system, or were they due to the presenting the information electronically? An additional data collection period was established to provide a tentative answer to this question. Six F-15 Assessors performed the assessment task under the same test and evaluation conditions and rules. For this test, subjects performed a conventional assessment with the use of JCALS standard IPDF TOs instead of paper TOs. The JCALS IPDF data was presented electronically with no additional enhancements or aids. This setup allowed collection of data that tentatively would be comparable to the ABDAR enhanced IPDF data and the paper data collected during the field test. To this end, the data were submitted to three one-way ANOVAs to determine any differences between the Media conditions of IPDF (IPDF with the ABDAR Demonstration System), Paper, and JCALS (IPDF without the ABDAR Demonstration System). As with the previous tests, the dependent variables were Time, Completeness, and Accuracy. Mean scores for the JCALS IPDF data were compared with the IPDF and paper collected in the main field test for the F-15 assessors. Overall results were consistent with the findings of the main test.

Time

The ANOVA for Time revealed no significant differences between subjects in the different media conditions (See Table B- 1).

Table B- 1 - Analysis of Variance Table – Time

Source		**Sum of**	**Mean**		**Prob**
Term	**DF**	**Squares**	**Square**	**F-Ratio**	**Level**
A: Media	2	41513.73	20756.87	1.02	0.388881
S	12	243511.6	20292.63		
Total (Adjusted)	14	285025.3			
Total	15				
*Term significant at alpha = 0.05					

These results are consistent with the field test. The significant speed difference between IPDF and Paper, observed in the field test results and not here, is attributable to the lack of the Other Assessor data. The trend in the data is the same; Paper is faster than IPDF. The addition of the JCALS condition provides no new insight into the data.

Completeness

The results of the ANOVA for completeness are shown in Table B-2. The ANOVA on the Completeness data showed a significant effect, F (2, 14) = 31.45, p = .0000. Subjects using IPDF recorded the most complete assessments ($\bar{x}$ = 93.8%), followed by subjects in the JCALS condition ($\bar{x}$ = 74.4) and subjects using Paper ($\bar{x}$ = 60.2). Bonferroni Multiple Comparison Tests showed significant differences between each of the media types.

Table B- 2 - Analysis of Variance Table – Completeness

Source		Sum of	Mean		Prob
Term	**DF**	**Squares**	**Square**	**F-Ratio**	**Level**
A: Media	2	2844.933	1422.467	31.45	0.000017*
S	12	542.8	45.23333		
Total (Adjusted)	14	3387.733			
Total	15				
*Term significant at alpha = 0.05					

As would be expected, subjects in the JCALS condition performed better than subjects in the Paper condition and worse than subjects in the IPDF condition. The convenience of the electronic TOs improved completeness when compared to Paper. However, the combination of electronic TO's and the ABDAR Demonstration System prove to be the best method for obtaining a complete assessment.

Accuracy

The ANOVA on the Accuracy data (See Table B-3) showed a significant effect, F (2, 14) = 38.58. p = .0000. Subjects using the IPDF media were the most accurate ($\bar{x}$ = 87.6%) followed by subjects using the JCALS standard electronic TO's ($\bar{x}$ = 58.2) with subjects in the Paper media condition performing assessments that were only 43.6% accurate. Bonferroni Multiple Comparison Tests reveal significant differences between the means of the IPDF subjects and both of the other media conditions, JCALS and Paper. The subjects in the JCALS condition did not perform significantly better than subjects in the Paper condition.

Table B- 3 - Analysis of Variance Table – Accuracy

Source		Sum of	Mean		Prob
Term	**DF**	**Squares**	**Square**	**F-Ratio**	**Level**
A: Media	2	5022.533	2511.267	38.58	0.000006*
S	12	781.2	65.1		
Total (Adjusted)	14	5803.733			
Total	15				
*Term significant at alpha = 0.05					

Again, the data analysis follows the trends present on the field test data. IPDF data combined with the ABDAR Demonstration system provided the most accurate assessment.

Summary

The collection and analysis of this data was important to answer one question: were the performance advantages of IPDF and CDM, as documented in the Field Test, due to the electronic TOs or due to their integration into the ABDAR Demonstration System?

The data gathered are entirely consistent with the results of the field test. They also seem to indicate that a significant portion of the performance advantage is attributable to the ABDAR Demonstration System. In other words, IPDF electronic TOs alone do not provide the same advantage that IPDF electronic TOs with the ABDAR Demonstration System do.

APPENDIX C – FIELD TEST SCHEDULE

Table C- 1 – Paper Schedule

Paper									
	Number	Media	Technician Type		M	T	W	T	F
Week 1	FM3	Paper	F-15 Mech		A	A			
Week 1	FM4	Paper	F-15 Mech		A	A			
Week 1	FA3	Paper	F-15 Assessor			B	B		
Week 1	OA2	Paper	Other Assessor				B	B	
Week 1	OA1	Paper	Other Assessor					C	C
Week 1	FA1	Paper	F-15 Assessor					C	C
Week 2	OA3	Paper	Other Assessor		A	A			
Week 2	FA2	Paper	F-15 Assessor		A	A			
Week 2	FA5	Paper	F-15 Assessor			B	B		
Week 2	OA4	Paper	Other Assessor				B	B	
Week 2	FM1	Paper	F-15 Mech					C	C
Week 2	FM6	Paper	F-15 Mech					C	C
Week 3	OA5	Paper	Other Assessor		A	A			
Week 3	FA4	Paper	F-15 Assessor		A	A			
Week 3	FM2	Paper	F-15 Mech			B	B		
Week 3	FM5	Paper	F-15 Mech				B	B	
Week 3	FA6	Paper	F-15 Assessor					C	C
Week 3	OA6	Paper	Other Assessor					C	C

Table C- 2 – Electronic One Schedule

Electronic One									
	Number	Media	Technician Type		M	T	W	T	F
Week 1	OA4	IPDF	Other Assessor		A	A			
Week 1	FA3	CDM	F-15 Assessor		A	A			
Week 1	FM2	CDM	F-15 Mech			B	B		
Week 1	FM5	CDM	F-15 Mech				B	B	
Week 1	FA5	IPDF	F-15 Assessor					C	C
Week 1	OA1	IPDF	Other Assessor					C	C
Week 2	OA5	IPDF	Other Assessor		A	A			
Week 2	FA6	CDM	F-15 Assessor		A	A			
Week 2	FA2	IPDF	F-15 Assessor			B	B		
Week 2	OA3	CDM	Other Assessor				B	B	
Week 2	OA2	CDM	Other Assessor					C	C
Week 2	FA4	IPDF	F-15 Assessor					C	C
Week 3	FM3	IPDF	F-15 Mech		A	A			
Week 3	FM6	CDM	F-15 Mech		A	A			
Week 3	OA6	IPDF	Other Assessor			B	B		
Week 3	FA1	IPDF	F-15 Assessor				B	B	
Week 3	FM1	CDM	F-15 Mech					C	C
Week 3	FM4	CDM	F-15 Mech					C	C

Table C- 3 – Electronic Two Schedule

Electronic Two									
	Number	**Media**	**Technician Type**		**M**	**T**	**W**	**T**	**F**
Week 1	OA1	CDM	Other Assessor		A	A			
Week 1	FA2	IPDF	F-15 Assessor		A	A			
Week 1	FA1	CDM	F-15 Assessor			B	B		
Week 1	OA2	IPDF	Other Assessor				B	B	
Week 1	FM3	CDM	F-15 Mech					C	C
Week 1	FM5	IPDF	F-15 Mech					C	C
Week 2	OA6	IPDF	Other Assessor		A	A			
Week 2	FM2	CDM	F-15 Mech		A	A			
Week 2	FM1	CDM	F-15 Mech			B	B		
Week 2	OA3	CDM	Other Assessor				B	B	
Week 2	FA4	IPDF	F-15 Assessor					C	C
Week 2	FA6	IPDF	F-15 Assessor					C	C
Week 3	FA5	CDM	F-15 Assessor		A	A			
Week 3	FM4	CDM	F-15 Mech		A	A			
Week 3	FA3	CDM	F-15 Assessor			B	B		
Week 3	FM6	IPDF	F-15 Mech				B	B	
Week 3	OA4	IPDF	Other Assessor					C	C
Week 3	OA5	IPDF	Other Assessor					C	C

APPENDIX D – DEMOGRAPHIC INFORMATION FORM

Demographics Questionnaire

ABDAR Field Test

1. Name:
2. Rank:
3. Stationed at:
4. Age:
5. Sex:
6. Years in Air Force:
7. Years of ABDR experience:
8. AFSC's:
9. Are you Color Blind? Yes No
10. Do you have experience with CAMS? Yes No
11. Do you have experience with CFRS (FR/FI)? Yes No
12. Do you have experience with other, similar, automated systems? Yes No
13. How would you rate your computer skills?

    Beginner (Little or no experience)

    Average (word processing, web browser, spreadsheet, etc.)

    Expert (extensive experience, programming, power user, etc.)
14. Squadron Commander's Name and mailing address:
15. Your Office Symbol:

APPENDIX E – EXIT QUESTIONNAIRE

Exit Questionnaire

ABDAR Field Test

1. What aspects of the ABDAR System were most helpful to you in performing your job?
2. What aspects of the ABDAR System did you dislike?
3. Are there any changes you would like to see made to the ABDAR System?
4. Are there any other concerns or comments that you would like to be known?

APPENDIX F - DATA COLLECTION SHEETS

PAPER ASSESSMENT DATA COLLECTION FORM

Subject Number:	
Session Number:	
Session Type:	
Monitor:	
Start Time:	
Stop Time:	
Total Time:	

Minutes to Tenths of Minutes Conversion					
1 or 2	0	21 thru 26	0.4	46 thru 51	0.8
3 thru 8	0.1	27 thru 33	0.5	52 thru 57	0.9
9 thru 14	0.2	34 thru 39	0.6	58 thru 60	Next Whole
15 thru 20	0.3	40 thru 45	0.7		Hour

UXO Inspection C/W

Inspecting Aircraft

START	STOP	HOURS	NOTE #

Researching Damage Data/Documenting Damage Description

START	STOP	HOURS	NOTE #

Researching Repairs Data/Documenting Repair Instructions

START	STOP	HOURS	NOTE #

Repair Planning

START	STOP	HOURS	NOTE #

IPB RESEARCH TIME

START	STOP	HOURS	NOTE #

WIRING RESEARCH TIME

START	STOP	HOURS	NOTE #

Note #	Time	Note

Electronic Assessment Data Collection Form

Subject Number:		**UXO Inspection C/W**	**Start Time:**	
Session Number:			**Stop Time:**	
Session Type:	PDF CDM	**UXO Inspection C/W**	**Total Time:**	
Monitor:	JJ LK			

Inspecting Aircraft (On-Aircraft)			
Start	**Stop**	**Hours**	**Note #**

Home Page			
Start	**Stop**	**Hours**	**Note #**

Detailed Inspection			
Start	**Stop**	**Hours**	**Note #**

Reviewing Debrief			
Start	**Stop**	**Hours**	**Note #**

Initial Inspection			
Start	**Stop**	**Hours**	**Note #**

Wiring Illuminator			
Start	**Stop**	**Hours**	**Note #**

Repair Selection			
Start	**Stop**	**Hours**	**Note #**

Repair Planning			
Start	**Stop**	**Hours**	**Note #**

Time Out			
Start	**Stop**	**Hours**	**Note #**

Documentation			
Start	**Stop**	**Hours**	**Note #**

Note #	**Time**	**Note**
1		
2		
3		
4		
5		
6		
7		

APPENDIX G – SUBJECT RULES

The following rules will be read to the subjects, before the experiment, and provided upon request at any time during the experiment. Specific sets of rules are provided for each media type being tested as well as a general set of rules applicable to all media types.

a. General

1. Individuals are not being tested nor are they in competition with any other individual(s). Different media types (paper, IPDF, and CDM) are the focus of the study.

2. **SAFETY FIRST.** All personnel will exercise extreme care while working around the aircraft, due to sharp edges and low areas. Caution and safety will be emphasized when climbing on ladders or working on top of the aircraft.

3. There will be **NO** simulated threats, nor will there be a requirement to wear any protective chemical warfare (CW) gear during the experiment.

4. Disregard any areas covered with speed (metal) tape.

5. DO NOT clean up any damages. Assume that any clean up will be accomplished as part of the repair, not as part of the assessment.

6. Assume that technicians are ABDR trained. This is for the sake of documentation of the repair to be accomplished. NOTE: The technicians have minimum experience in repairing this type of damage. Therefore, supply a more detailed instruction set. ***Remember:*** You will not be the repair technician!

7. DO NOT write on the aircraft. Use paper and tape it to the aircraft at the locations you need to document. (Due to varied locations, test monitors cannot accomplish this before the test.)

8. DO NOT write in the Technical Orders (TOs). If any marks are found in the TO, point them out to the monitor so they can be erased.

9. DO NOT discuss the tasks performed, equipment/methods used, any difficulties experienced, the specifics of the study or anything seen or heard during this experiment with co-workers, other test subjects, etc. This restriction applies until all field test data collection has been completed.

10. During lunch and other breaks, try not to continue to "work" the session. Because we are gathering times as part of the Data Collection, we need to have an accurate measurement of the time involved in assessing the damages. This includes the time spent thinking about the problem.

b. Paper

1. To order tools and/or materials or parts not available in the Tools and Materials kit, research the needed information and fill out an AF Form 2005 or AF Form 2413 and give it to the data collector. It will be issued or back ordered per the requirements of the Field Test.

2. Document information pertaining to damages, when appropriate, in Blocks 16 through 29 of the AFTO Form 97.

3. Use AF Form 2406 to indicate all required Operational Checks in the planned sequence for repairs.

4. Use AF Form 2406 to indicate which repairs you plan to accomplish concurrently.

5. Specify a planned start and stop time for all repairs.

6. Use AF Form 2406 to specify the planned use of resources.

c. Electronic - CDM and IPDF

1. Include all Operational Checks in repair planning.

2. Order any needed parts or materials not available in the Tools and Materials kit via the Portable Maintenance Aid (PMA). The results will be sent via electronic means.

3. The assessment portion of the documentation must be reviewed by the test monitor to validate that all damages were found. This must be accomplished before the session ends.

4. Plan the use of resources along with the task needed to accomplish the repair.

5. These will be printed out or saved as an electronic file. They will become part of the Data Collection data. They will be used for evaluation and analysis.

APPENDIX H – MONITOR RULES

Be ready to point out any damage(s) missed when the subject attempts to hand in the completed assessment. If more than one damage is missed, point out all missed damages at the same time. Allow them to complete the missed damage(s). Record which damage(s) were missed with individual time measurements for those missed.

Record any help given and classify the help. Indicate whether an explanation was given or just the location of the information.

Keep technical interaction with the subject to a minimum. Document when interaction occurs and what it entailed. (No social interaction, small talk, etc. either)

Enter the required data on the Data Collection Sheet and compute total time for session. Note any reason for work stoppage, including the relevant times. Things such as breaks, lunch, etc. should have a start and stop time noted. (Also, record times at key points and stop/start times for breaks.)

APPENDIX I – SCENARIO 1 – PAPER LEFT SIDE

- Scenario 1 - Paper Left Side
  - You have been assigned as the assessor for aircraft 76-0012 L (L is the left side only).
  - The aircraft has been battle damaged and Debrief has been accomplished by another individual using the F-15 CFRS debrief system.
  - The AFTO Forms (97 and 781A) have been annotated with this debrief information and correctly describe the failures experienced.
  - The aircraft is needed ASAP as lead for a four ship Air to Air night mission, with no degraded performance.
  - The aircraft must be tanker capable.
  - You have a limited number of TOs available at this work site. Any additional TOs required should be requested from the Production Superintendent.
  - You have available a partially stocked war wagon, all needed tools, all needed powered and non-powered Aircraft Ground Equipment (AGE), and some personnel (see roster below).
  - You have access to base supply for parts ordering and access to a Pro Super for information and resources.

Personnel	Specialty	Available	Special Qualifications
Subject name	Subject specialty	Yes	
SSgt Miller	Elect. Assessor	No	
SSgt Smith	SM Assessor	No	
SrA Crum	APG ABDR Technician	Yes	Eng. & Hyd. Cut
SrA Cole	Fuel ABDR Technician	Yes	
Capt Clark	ABDR Engineer	Yes	

APPENDIX J – SCENARIO 2 – PAPER RIGHT SIDE

- Scenario 2 – Paper Right Side
  - You have been assigned as the assessor for aircraft 76-0012 R (R is the right side only).
  - The aircraft has been battle damaged and Debrief has been accomplished by another individual using the F-15 CFRS debrief system.
  - The AFTO Forms (97 and 781A) have been annotated with this debrief information and correctly describe the failures experienced.
  - The aircraft is needed ASAP as lead for a four ship Air to Air night mission, with no degraded performance.
  - The aircraft must be tanker capable.
  - You have a limited number of TOs available at this work site. Any additional TOs required should be requested from the Production Superintendent.
  - You have available a partially stocked war wagon, all needed tools, all needed powered and non-powered AGE, and some personnel (see roster below).
  - You have access to base supply for parts ordering and to a Pro Super for information and resources.

Personnel	Specialty	Available	Special Qualifications
Subject name	Subject specialty	Yes	
SSgt Miller	Elect. Assessor	No	
SSgt Smith	SM Assessor	No	
SrA Crum	APG ABDR Technician	Yes	Eng. Run Qual.
SrA Cole	Fuel ABDR Technician	Yes	Instruments Cut Trained
Capt Clark	ABDR Engineer	Yes	

APPENDIX K – SCENARIO 3 – CDM/IPDF LEFT SIDE

- Scenario 3 – CDM/IPDF Left Side
  - You have been assigned as the assessor for aircraft 76-0012 L (L is the left side only).
  - The aircraft has been battle damaged and Debrief has been accomplished by another individual using the F-15 CFRS debrief system.
  - The paper AFTO Forms 781A and the electronic equivalent AFTO Form 97 have been annotated with this debrief information and correctly describe the failures experienced.
  - The aircraft is needed ASAP as lead for a four ship Air to Air night mission, with no degraded performance.
  - The aircraft must be tanker capable.
  - You have available a partially stocked war wagon, all needed tools, all needed powered and non-powered Aircraft Ground Equipment (AGE), and some ABDAR personnel.
  - You have a connection to base supply for parts ordering and access to a Pro Super for information and resources.
  - All communications needed with Pro Super, Team Chief, Engineer, Technicians, Supply, Support, etc. must be accomplished electronically.

Personnel	Specialty	Available	Special Qualifications
Subject name	Subject specialty	Yes	
SSgt Miller	Elect. Assessor	No	
SSgt Smith	SM Assessor	No	
SrA Crum	APG ABDR Technician	Yes	Eng. & Hyd. Cut
SrA Cole	Fuel ABDR Technician	Yes	
Capt Clark	ABDR Engineer	Yes	

APPENDIX L – SCENARIO 4 – CDM/IPDF RIGHT SIDE

- Scenario 4 – CDM/IPDF Right Side
  - You have been assigned as the assessor for aircraft 76-0012 R (R is the right side only).
  - The aircraft has been battle damaged and Debrief has been accomplished by another individual using the F-15 CFRS debrief system.
  - The paper AFTO Forms 781A and the electronic equivalent AFTO Form 97 have been annotated with this debrief information and correctly describe the failures experienced
  - The aircraft is needed ASAP as lead for a four ship Air to Air night mission, with no degraded performance.
  - The aircraft must be tanker capable.
  - You have available a partially stocked war wagon, all needed tools, all needed powered and non-powered Aircraft Ground Equipment (AGE), and some ABDAR personnel.
  - You have a connection to base supply for parts ordering and access to a Pro Super for information and resources.
  - All communications needed with Pro Super, Team Chief, Engineer, Technicians, Supply, Support, etc. must be accomplished electronically.

Personnel	Specialty	Available	Special Qualifications
Subject name	Subject specialty	Yes	
SSgt Miller	Elect. Assessor	No	
SSgt Smith	SM Assessor	No	
SrA Crum	APG ABDR Technician	Yes	Eng. Run Qual.
SrA Cole	Fuel ABDR Technician	Yes	Instruments Cut Trained
Capt Clark	ABDR Engineer	Yes	

APPENDIX M – EVALUATIONS

1. Damage Collection Evaluation

a. **The Structure Table.** The structure table contains the name (type) of the structure, the type of material it is composed of, and the category of the structure. Using the extent of the damage (size and number of holes, dents, cracks, etc.) and comparing the damage to the limits shown in the table for each component, the Class of damage can be determined. To make this comparison, a calculation of a "k factor" may be required. From this information, the assessor must document the damage. The following is a suggestion on how to evaluate the documentation to determine if it meets the minimum, as described by TO 1-1H-39.

(1). Name: Was the name from the table used? If not, was the name used sufficient to identify what component was damaged?

(2). Location: Was Waterline (WL), Butt-line (BL), and Fuselage Station (FS) used to determine the location of the damage? If not, was the location described using measurements from easily identified references? Was it sufficient in describing the location of the damage?

(3). Category: Was the category of the damage recorded? (To allow another assessor to continue, he needs to know the category of each assessed structure. This allows him to identify the highest category of damaged structure and annotate the AFTO Form 97 without having to look each assessed structure up again.)

(4). Extent of damage: Was the size of the damage, number of damages included in this damage (if more than one), and k factor (if applicable) recorded? Was type (hole, dent, nick, etc.) of damage identified?

(5). Class: Was the Class of the damage recorded? (The extent of damage when compared to the table will give the Class. The Class of the damage is needed for the same reason that the damage Category is needed. The Class identifies the possible (required) repairs.)

b. **The System Table.** The System Table shows a name, acceptable damage limits, possible repairs, method of determining the function impact, and restriction/impact if functional impact is not fixed. Another table, in the 1F-15A-39, shows serviceability criteria (impact) for both types of missions (Air to Air and Ferry).

(1). Name: Was the name from the table used? If not, was the name used sufficient in identifying what component was damaged?

(2). Extent of damage: Was damage described to the detail needed to allow another assessor to recognize it? Was functionality in question? If so, was functionality determined during the assessment or was an evaluation part of the repair?

(3). Location: Was location of damage on the system described in sufficient detail that the damage could be found by other ABDR personnel?

(4). Serviceability criteria: was criteria needed for missions recorded?

c. Documentation for **damaged wiring** is somewhat more difficult than damaged structures and systems. Based on observation and feedback, the following is the minimum set of information needed for another assessor to continue an assessment:

(1). Name: Was the bundle number or plug number used to identify the damaged component?

(2). Location: Was the location of damaged wiring recorded in sufficient detail that the damage could be found?

(3). Extent of Damage: Was the description of the damage sufficient? Was the type of damage (nicked, cut, etc.) indicated? Was the number of damaged wires identified?

(4). Serviceability criteria: Were potentially affected systems noted? Were each system's criteria for missions noted? Were systems identified that had to be fixed and/or deactivated?

2. Repair Instructions Evaluation

a. Each repair must have a complete description of the repair to be accomplished. These descriptions shall include such things as the TO figure references, hardware (material) required, diagrams of structural patches showing fastener requirements, etc. In all cases, the assessor shall include as a minimum the repair's TO reference (figure, paragraph, etc.), number and type of fasteners required (if applicable), and any peculiar requirements not contained in the TO reference. If an engineer repair is used, the engineer's name and grade must be printed after the repair instructions. TO 1-1H-39 contains the following instructions:

(1). Was the repair annotated as to which damage it fixed?

(2). Was the proper repair decision made based on mission and serviceability criteria?

(3). Were resources (parts, material, personnel, etc.) considered in making the repair decision?

(4). Did the repair contain the correct TO reference?

(5). Structure: Did the repair contain the number and type of fasteners? Did it contain the type and thickness of material to use? Was a fastener layout given?

(6). System: Was a method given to determine functional impact (if in question)? Was the appropriate action given if the functional impact was known or was the appropriate action given after a functional impact was proven?

(7). Wiring: Were all affected systems identified to be fixed and/or deactivated?

3. Repair Planning Evaluation

a. Sequencing: Were all repairs planned? Were all physical and functional considerations correctly considered? Were all resource conflicts correctly considered?

b. Timing: Did the planned repair times equal the estimated repair times?

4. Other Evaluations

a. Was UXO inspection signed off before starting inspections?

b. Were the highest Class and Category noted? Were they correct?

c. Were estimated times recorded for damages? Were they within a valid range?

5. Overall Evaluation Matrix. The evaluation matrix for Damage Site One (APPENDIX N) and Damage Site Two (APPENDIX O) show the evaluation elements common or unique to each type of damaged component (Structure, System, and Wiring). We have used this in developing our overall scoring scheme. The matrix shows each element is worth one point for each component within a damage type. This means the total for the damage site in the Avionics Bay is worth approximately 400 points while the damage site in the wing is worth approximately 200 points. This difference reflects the difference in the number of actual damages within each site. Damage site one contains 14 damages and damage site two contains eight.

APPENDIX N – DAMAGE SITE ONE EVALUATION MATRIX

Damage Collection Evaluation

Inspecting A/C	Annotated?	Accurate?					***Totals***
UXO Inspections	1	1					
Damage Found DS1?	14						16
Other Documentation Requirements							
	Annotated?	Accurate?					
Highest class?	1	1					
Most critical Cat?	1	1					
Engineer Contacted?	1	1					
Estimated times?	5	5					16
	Structure		System		Wiring		
Structure (7)	Annotated?	Accurate?	Annotated?	Accurate?	Annotated?	Accurate?	
Name	1	1					
Location	1	1					
WL - BL - FS - WS							
From Reference							
Category	1	1					
Extent	1	1					
Size							
K-factor							
Class	1	1					
							70
System (5)							
Name			1	1			
Location			1	1			
Extent			1	1			
Serviceability Criteria							
A - A			1	1			
Ferry			1	1			
							50
Wiring (2)							
Name					1	1	
Bundle #							
Plug #							
Location					1	1	
Extent					1	1	
Serviceability Criteria							
A - A					1	1	
Ferry					1	1	
							20

Appendix N - Damage Site One Evaluation Matrix (cont.)

Repair Instructions Evaluation

	Structure		System		Wiring		
	Annotated?	Accurate?	Annotated?	Accurate?	Annotated?	Accurate?	
Repair ID'ed to damage	1	1	1	1	1	1	
System Parts Ordered (5)			1	1			
TO Reference or Engineer Name Requirement	1	1	1	1	1	1	
							66
Structure (4 of 7)							
Type/No. of fasteners	1	1					
Type/Thickness of material	1	1					
Fastener layout given	1	1					
							24
System (5)							
Functionality Evaluated?			1	1			
Correct Repair Action?			1	1			
							20
Wiring (2)							
Systems/Wires Id'ed to Repair					1	1	
Fix							
Deactivate							
							4

Repair Planning Evaluation

	Structure		System		Wiring		
	Annotated?	Accurate?	Annotated?	Accurate?	Annotated?	Accurate?	
Sequenced Considered							
Physicial	1	1	1	1	1	1	28
Resources	1	1	1	1	1	1	28
Planned = Estimated times	1	1	1	1	1	1	28
							370

APPENDIX O – DAMAGE SITE TWO EVALUATION MATRIX

Damage Collection Evaluation							
Inspecting A/C	Annotated?	Accurate?					***Totals***
UXO Inspections	1	1					
Damage Found DS2?	8						
							10
Other Requirements							
	Annotated?	Accurate?					
Highest class?	1	1					
Most critical Cat?	1	1					
Engineer Contacted?	1	1					
Estimated times?	5	5					
							16
	Structure		System		Wiring		
Structure (2)	Annotated?	Accurate?	Annotated?	Accurate?	Annotated?	Accurate?	
Name	1	1					
Location	1	1					
WL - BL - FS - WS							
From Reference							
Category	1	1					
Extent	1	1					
Size							
K-factor							
Class	1	1					
							20
System (4)							
Name			1	1			
Location			1	1			
Extent			1	1			
Serviceability Criteria							
A - A			1	1			
Ferry			1	1			
							40
Wiring (2)							
Name					1	1	
Bundle #							
Plug #							
Location					1	1	
Extent					1	1	
Serviceability Criteria							
A - A					1	1	
Ferry					1	1	
							20

Appendix O - Damage Site Two Evaluation Matrix (cont.)

Repair Instructions Evaluation

	Structure		System		Wiring		
	Annotated?	Accurate?	Annotated?	Accurate?	Annotated?	Accurate?	
Repair ID'ed to damage	1	1	1	1	1	1	
Parts Ordered			1	1			
TO Reference or Engineer Name Requirement	1	1	1	1	1	1	
							40
Structure (2)							
Type/No. of fasteners	1	1					
Type/Thickness of material	1	1					
Fastener layout given	1	1					
							12
System (4)							
Functionality Evaluated?			1	1			
Correct Repair Action?			1	1			
							16
Wiring (2)							
Systems/Wires Id'ed to Repair					1	1	
Fix							
Deactivate							
							4

Repair Planning Evaluation

	Structure		System		Wiring		
	Annotated?	Accurate?	Annotated?	Accurate?	Annotated?	Accurate?	
Sequenced Considered							
Physicial	1	1	1	1	1	1	16
Resources	1	1	1	1	1	1	16
Planned = Estimated times	1	1	1	1	1	1	16
							226

APPENDIX P – EXIT QUESTIONNAIRE COMMENTS - COMPLETE

Question 1. What aspects of the ABDAR System were most helpful to you in performing your job?	
Context	Comment
Documentation General	Easy to find data when needed. One touch system.
Documentation General	Being able to compile before you begin to fill the 97 out completely. It could be a useful tool once the bugs and desirable hardware become available.
Documentation Research	I like how it takes care of filling out the AFTO 97's. Really like the way it takes you to the specific TO area you need to be in, links are very useful
General	The entire system would be a good tool to perform ABDR assessment and repairs.
General	It made me realize what problem areas I have in assessing actual battle damage.
General	The speed in which it performs the task. The way the screen won't switch over unless you process the work correctly.
General Communications	The laptop computer with all necessary assessor tools loaded on the hard drive, i.e. (TO's, forms). Also being able to communicate with others from the terminal.
General Part Ordering	The auto catalog system in the program and the parts breakdowns.
General TO Research	Better assessments can be made using ABDAR, TO's were great.
General TO Research	The system was the most help in the inspection and repair selection area. Also, not having to wade through several TO's helped.
K-Factors TO Research Part Ordering	K-factors automatically figured for you. No research req. with this system. Extremely quick ordering
K-Factors TO Research Wizards	Having the TO in the computer, k-factor calculator and wizard helped me greatly because I'm not an assessor.
TO Research	Integrated tech data (no big books).
TO Research	TO's being in the computer, reduces a lot of time looking through books.
TO Research	Electronic versions of the tech. orders and the outlined figure blocks that linked me to the tech. data.
TO Research	"Online" tech data.
TO Research	Being able to go to the TO quickly to get the information needed.
TO Research	The elimination of paper tech orders.
TO Research	Information about each repair installed on the computer.
TO Research	The graphics really helped.
TO Research	Electronic TO figures on the computer with part numbers.
TO Research Documentation	It made it easy as far as CAT damages, and less paper work.
TO Research Part Ordering	The menu for where the aircraft damage was. Not having to look up part #'s.
TO Research Planning General	Convenience of references. Accurate tracking of jobs and resources. Will enforce "completeness" in training as well as on the job assessments.
TO Research Usability	SPEED. Not having to research through different TO's and wiring diagrams saved loads of time. EASE OF USE
TO Research Wiring Decision Making	Having a diagram and a complete breakdown of damaged area. Wiring breakdown was very helpful. Automatically deciding if engineer was necessary was good.
TO Research Wizards	Wizard, TO's on the computer.
Usability	Set up like windows, which makes it easy to learn.
Usability	Reducing the task of carrying (physically) TO's around the work areas.
Usability	Portability of the laptop.
Usability	System is portable right to the aircraft. This made it easy to compare the graphics to the actual damaged areas.
Wiring	Being able to have the wiring diagram at a click of a button!
Wizards	ABDAR Wizard and ABDAR Manual.
Wizards	It didn't let you miss anything

Question 2. What aspects of the ABDAR system did you dislike?	
Data	No TO's in the CDM.
Data	Lack of reference data.
Data	Not having detailed parts, i.e., fittings had no sizes that were recognizable at a glance.
Data	It is too vague in the actual repair areas.
General	None
General	None
General	I liked the system. Keep fine-tuning and improving your product.
General	None
General	All features seemed very worthwhile.
General	None
General	Really none, just takes time to get used to the system.
General	None
General	None
General	None
General	None
General	Not being totally comfortable with ABDAR and computers.
Hardware	Wizard Finger mouse
Known Problems	When selecting materials etc. It not being in alpha order.
Known Problems	There were a few kinks with server, which happens.
Known Problems	TO pages are hard to read, when you enlarge its easy to lose your spot.
Known Problems	System slowed to a crawl or even locked up after a few hours of use. I realize that the system is still under development though.
Known Problems	Nothing about the system. I would like to see the hourglass to let me know the computer is working.
Known Problems	The speed of the computer, in a real situation, it is possible to have a great deal more damage. This will require a faster and more reliable system.
Known Problems Hardware System Design	Speed, information had to be entered more than once and the touch sensor mouse.
Planning	Showing the repair planning was not need for assessor to his job would save time if this went to Job Control or Pro Super.
System Design	Having to allocate twice instead of once for resources.
System Design	The jumping between different screens.
System Design	Repetitiveness - having to send a low pack to the aircraft 10 separate times.
System Design	The scheduling and repetitiveness with repair selection in the resource fields.
System Design	Repetitive system.
System Design	The system was often slow at times.
System Design Known Problems	If a UXO is found during area UXO inspection. General UXO and Safe for Maintenance Inspection should be opened back up. Color of all scroll bars should be gray not blue - whatever (should stand out better).
Hardware	If a repair description is not complete and you want to move to another repair, you should be allowed to get back to the original repair and pick back up where you left off. Not start all over again. Touch pad is bad! Should be mouse or track ball. Not touch pad!! Wizard is sometimes a bother. It should be an option not a must use. The more advanced you get the less one is to use any wizard. Data transmission is very slow. Needs to be faster for the use to be useful.
Usability	More training time.
Wizards	The wizard was a little confusing at times but it helped me a lot.

Question 3. Are there any changes you would like to see made to the ABDAR System?	
Data	More selections of materials and equipment.
General	Looks good!
General	No

General	No
General	No
General	Yes
General	No
General	No
General	No
General	No
Hardware	Sensor touch screens in which you can use a pointer.
Hardware	Maybe, install as track ball type mouse.
Hardware Data	Maybe if computers were faster. Some items in equipment were actually materials and vise versa.
High Tech	Incorporate digital camera so you can take a snapshot of damage and have available if needed, this would prevent returning to the aircraft as much.
Implementation	Implement [integrate?] this system to IMDS.
Known Problems	Have the program written in a more stable version of JAVA.
Known Problems General	Work out the bugs!
Planning	Task scheduling is not a needed feature. Allocating resources is not a need in the field.
System Design	When a qty of 60 for fasteners is needed, then when you allocate you should not need to allocate 60 times for 60 fasteners. A block needs to be added for any deviations and work stoppage.
Planning System Design	I would like to be able to transfer equipment and materials from the needed to the allocated block in repair planning component.
Planning System Design	I would like to see the scheduling go away. More of the management level tool, than lower level.
Planning System Design	Once the assessor is complete the team chief should schedule people.
System Design	None other than if it could all be put on one screen.
System Design	I know it will be enhanced in the future and will become more user friendly.
System Design	More user friendly, i.e. hyperlinks.
System Design	Drop and drag features; better way to highlight comments and restrictions; possibly like web links.
System Design	Give equipment list a memory.
System Design	Some kind of warning to contact an engineer if damage limits are exceeded.
System Design	Areas where the "double click" option could be used are in the equipment, personnel and material selections. Some areas where you could answer more than one question on one screen.
System Design High Tech	Better user friendly controls with voice and video links (if possible).
Usability	More training time
View of Data	If possible, to create an exploded view of all damage area's (like the wiring diagram) to zoom in with.
View of Data	Add a pictorial feature for viewing damages.
View of Data	Better graphics

Question 4. Are there any other concerns or comments that you would like to be known?	
AF Infrastructure	Make one system and improve on that system. TO's should be all standardized. Not fighters, bomber, airlift, i.e., if 27 is for flight controls then it should be for each weapon system.
Data	Having all TO's listed in each system TO (-39) as well as peacetime books in the computer (or on disk, internet) will assist with fixing all aircraft in our inventory.
Field Test Team	I would like to express my sincere appreciation, for the kindness, courtesy, and tremendous support the entire ABDAR team provided!
Field Test Team	The training/experiment staff was extremely courteous and helpful and really makes using this system an easy task. Very professional image.
General	Overall it looks like a good system in work, and should be used, not only ABDR, but in regular maintenance as well. I think that a different program should be made for each different AFAC (shop). In the future of course.
General	Neat system, think it would work fine on any of our aircraft now.

General	None
General	I personally need more training to give a better viewpoint on what we really need. Overall it is a vast improvement over having to physically search for info and manually document forms
General	No
General	No
General	No
General	No
General	Awesome product, it was a lot of fun!
General	I learned a lot and hope the Air Force buys this program.
General	None
General	None
General	I think it is an excellent program. I think it should be helpful to the assessors who understand the setup and material.
General	No
General	None
General	Make it so! In other words make it happen as soon as possible.
General	None
General	No
General	I think this is an outstanding program. This will make my job as an assessor easier. Not to mention the time factor in returning the aircraft back to service.
General	Very helpful system to the assessor.
General	The new system is great. It will save time and money in the long run.
General	Other than the known bugs it's a great system.
General	No
General Documentation	I enjoyed this test. It broke down what one thinks and puts it on paper. This way, things have a less chance of being overlooked.
System Design Planning	Scheduling the jobs would be easier on paper.
Usability	I think the ABDAR system as it is right now will give too much flexibility to the technician doing the repair and it could cause an inadequate repair being installed on the aircraft.
Usability Hardware	Make it easier for a non-sheet metal person to be able to identify rivets, metals, etc. I worry about how long the laptop will last on a flightline environment. (Being dropped, impractical). How will the system work in a chemical environment with chemical gear on?
View of Data	Measurement data: While most is very similar, there are differences that can change the status of damage if not computed correctly. Perhaps, have the ABDAR wizard reference this data for the particular aircraft being assessed.
View of Data	It was a bit difficult to specify an exact wire or hydraulic line in a particular area. I can't imagine how much more difficult it will be if ALL the lines and ALL the wiring were to be added. It would definitely take a person with experience on this airframe to pinpoint specific wires or lines once they all get added, or even a specialist on that system.
View of Data	If the wizard followed automatically would be helpful if computer could automatically list type of material used in the area it is told, i.e., type of metal and thickness of the door on F-15 nose.